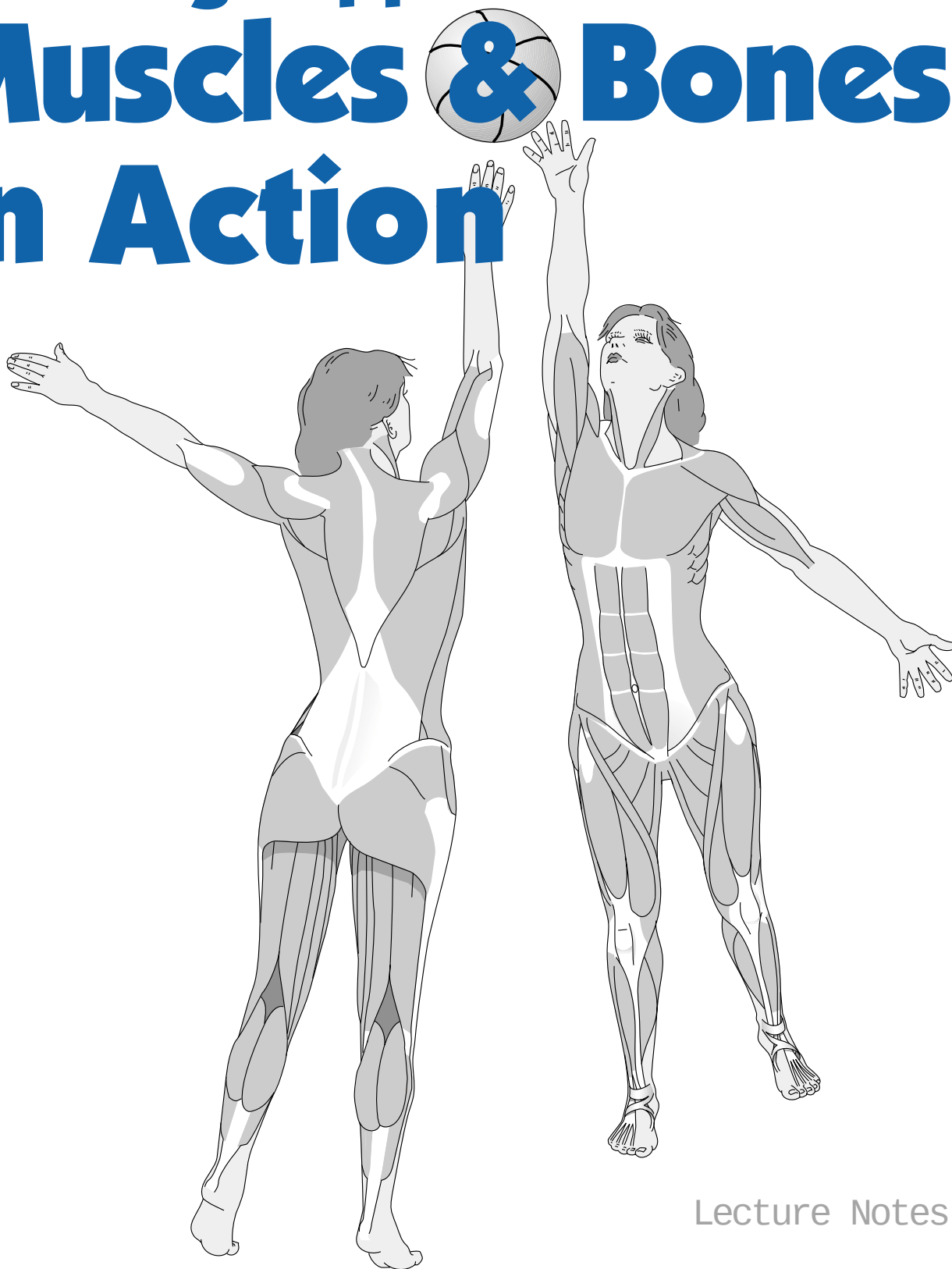


'A' Level PE & Sport Studies

Teaching Support Pack

Muscles & Bones in Action



Lecture Notes

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Introduction

The following pack is designed to help the teacher present the anatomical aspects of human movement in a stimulating way, with the notes being complemented by high quality full coloured OHTs based on the anatomical illustrations in Exercise Physiology by Colin Clegg.

The Skeletal System

Bone growth

Before birth, the skeleton is made up of cartilage, which is much softer and more flexible than bone. After birth, the cartilage of the skeleton is gradually replaced by bone in a process of ossification. While the main structure of the 'bones' still contains cartilage growth regions, they can continue to grow in length. However, once this cartilage has been replaced by ossification, the bones cannot grow in length any more. The closure of the cartilaginous growth regions in the long bones marks the end of growth in height of the individual. Bones can continue to grow in girth however, and do so when exposed to some continuing stress. Bone is largely composed of collagen fibres, the same as are found in tendons, and is hardened only by the deposition of calcium compounds eg calcium phosphate.

System Components

The skeleton is made up of more than 200 bones which articulate with each other at joints. In the skeleton, ligaments join bones to bones, tendons attach muscles to bones, and the ends of the bones in most joints are protected from wear by cartilage.

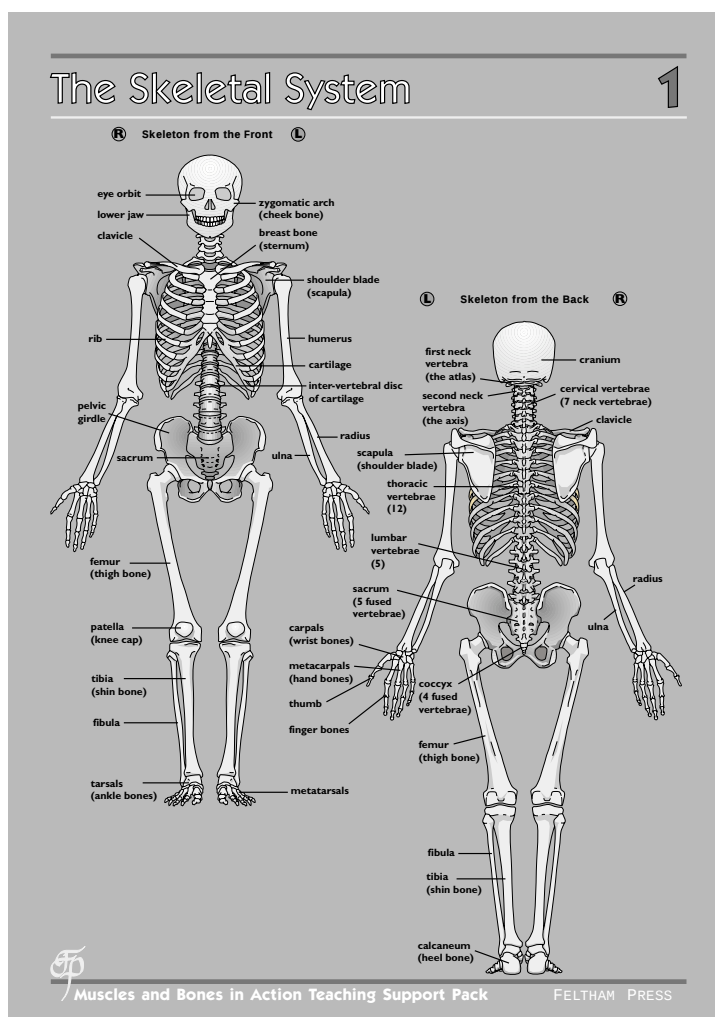
Functions

Functions of the skeleton include:

- ◆ Support of 'the body' of which it is an integral part of course, including movement by providing points of attachment for skeletal muscles.
- ◆ Protection of vital organs and systems.
- ◆ Production of red and white blood cells in the red bone marrow, which at birth is found in the centre of most bones, but is gradually replaced by non-productive fatty 'yellow' bone marrow until in the adult the productive red bone marrow is restricted to various 'short' bones such as the ribs.

Types of Bones

Image 1



Shape & Function

Long Bones

Bones can be grouped by their shapes, which are linked to their different functions.

These are found in the limbs, eg. the humerus, radius, and ulna, in the arms. Their main function is to work as levers, to increase the range of movement caused by the contraction of muscles.

Short Bones

These are found in the wrist and ankle joints, which are very complex with many short bones, which is why ankle and wrist injuries take so long to heal.

Irregular Bones

These have a wide variety of complex shapes, for example the vertebrae of the backbone, and the ribs. The vertebrae of the different regions of the backbone are adapted for different functions. The neck vertebrae allow movements of the head, and this mobility renders them prone to injury. The vertebrae in the lower back are larger and stronger than those in the neck, and allow less movement as they support the weight of the body. However, despite their strength and relative immobility, lower back problems are common.

Plate Bones

These are broad, flat bones, designed to protect special areas, for example some of the bones of the cranium protecting the brain; and for the attachment of broad origins of muscles, for example the shoulder blades.

The Muscular System

Types of Muscle

There are three main types of muscle in the body, each adapted to a specific way of working.

Involuntary Muscle

Involuntary muscle is not under our conscious control, in other words we cannot make it do what we want. It forms sheets or layers in the walls of hollow structures eg. in the gut, the bladder, and the walls of the blood vessels – especially the arteries. The only place where involuntary muscle can be observed from the outside of the body is in the iris of the eye, which dilates and constricts the pupil.

Cardiac Muscle

Cardiac muscle is found only in the heart, and is also not under conscious control. The rate of contraction of the heart can only be altered by the autonomic (*automatic*) nervous system, and by hormones (*eg. adrenaline*). Cardiac muscle fibres have interconnections between them, which allow for the rapid and co-ordinated contraction and relaxation of all the fibres together, so that the whole heart beats in a rhythmic way.

Cardiac muscle can only carry out respiration with oxygen. It cannot, therefore, develop an 'oxygen debt' by producing lactic acid as a result of anaerobic respiration, like voluntary muscles can. In fact, lactic acid, produced by voluntary muscles of the body which are working anaerobically during exercise, is used by cardiac muscle as a source of energy for its contractions.

Voluntary or Skeletal Muscle

Voluntary or Skeletal muscle is under our conscious control, and we can decide to move in certain ways by contracting various muscles. Voluntary muscle is connected to the skeleton via relatively non-elastic tendons. There are more than 650 skeletal muscles in the body.

Each voluntary muscle is a mixture of fast twitch and slow twitch muscle fibres. Fast twitch fibres contract faster than slow twitch, and can work anaerobically without oxygen, using glycogen. Slow twitch fibres work aerobically using fats more than glycogen. Sprinters and games players tend to have a greater proportion of fast twitch fibres, and endurance performers tend to have more slow twitch fibres. The proportion of the fast twitch and slow twitch fibres is genetically fixed, and is not affected by training.

Muscle Fibre Arrangement

Muscle fibres are bound by connective tissue into bundles. Within these bundles the fibres are all parallel to the longitudinal axis of the muscle. However, different muscles have these bundles arranged in differently. This pattern, along with the particular attachment of the muscle to the skeleton, determines the force and range of movement that can be produced. Two contrasting muscle bundle arrangements are fusiform muscles and pennate muscles.

Fusiform

These have comparatively less bundles of fibres which are relatively long, arranged side by side along the length of the longitudinal axis of the muscle, running into flat, strap-like tendons at each end. This arrangement allows the whole muscle to contract to its shortest possible length. This fusiform muscle type is attached in positions that results in rapid and wide ranging movements. An example is seen in the biceps brachii which flexes the arm.

Pennate

These have shorter bundles radiating out from a tendon that extends the length of the muscle. Muscle fibres can contract to just over half of their resting length. Since pennate bundles are shorter, contracting half of their length does not create as much movement as a longer fusiform muscle contracting to half its length. However, as there are relatively more bundles of muscle fibres in pennate muscles, they can contract more forcefully. Pennate muscles are frequently attached in positions that can result in powerful movements, for example the rectus femoris (*one of the 'quadriceps'*) of the thigh, which straightens the leg at the knee.

Muscle Attachment

Muscles are attached to the skeleton in a variety of ways. In most cases, particularly in the limbs, they have an 'origin', and an 'insertion'.

Muscle origins

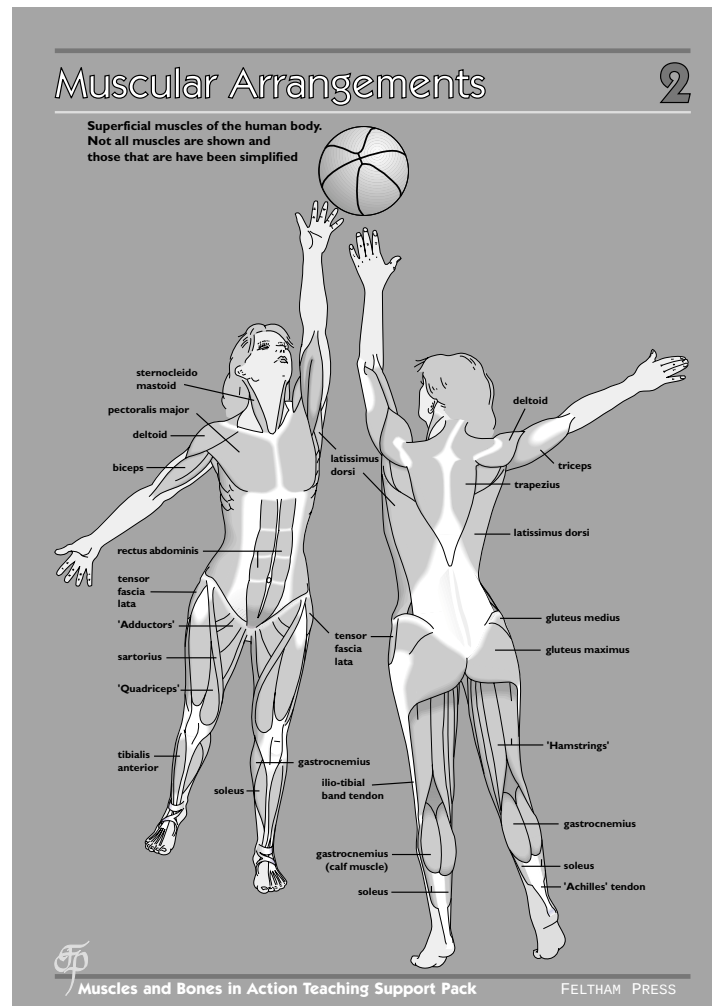
The end of a muscle which is attached at the relatively 'fixed' end of the bone is known as its origin. In the limbs this means that the origins of muscles are the ends nearest the trunk, 'above' the joint being moved. For example, the origin of the biceps muscle is on the scapula, and the origin of the triceps is on the humerus and the scapula. In the muscles of the trunk itself the situation may not be so clear.

Muscle insertions

The end of a muscle which is attached at the relatively 'mobile' end of the bone is known as its insertion. In the limbs this means that the insertions of muscles are the ends furthest from the trunk, 'below' the joint being moved. For example, the insertion of the biceps muscle is on the radius, and the insertion of the triceps is on the ulna. As with the origins, in the muscles of the trunk itself the situation may not be so clear.

Muscle Arrangements

Image 2



Antagonistic Pairs

The muscles act in groups rather than singly, with most arranged in opposed or **antagonistic pairs** at joints, for example flexors and extensors. The muscle that causes the required action is called the prime mover or **agonist** (*protagonist*), for example the biceps brachii flexing the arm at the elbow. At the same time the **antagonist** muscle, in this case the triceps brachii, is inhibited and relaxes, allowing the flexion to occur. If the arm is extended at the elbow, then the roles of agonist and antagonist are reversed, with the triceps brachii being the agonist, and the biceps brachii being the antagonist.

Fixators

Muscles known as **fixators** or **stabilisers** hold or fix joints in a stable position, as for example when keeping the wrist stiff during a biceps curl with weights.

Synergists

Others known as **synergists** prevent any unwanted movement and help the prime mover to function more efficiently.

Types of Muscle Action

Different Actions

The interaction of muscular forces, the load or resistance, the action of the bones as levers, and the action of the joints involved, determines the different actions.

Although the sliding filament mechanism must be active for a muscle to develop a force, the sarcomeres (*and the muscle as a whole*) do not always shorten. If the force that they generate is greater than the resistance, then they will shorten. If the force they generate cannot overcome the resistance they will not shorten; and if they are overcome by the resistance they will actually lengthen under tension.

Dynamic Actions (*Isotonic*)

These are the most common type, resulting in movement at the joints. There are two types; concentric and eccentric.

Concentric Action

These are perhaps the most familiar types of contraction, in which the whole muscle shortens as it develops tension. This type of contraction is seen for example in the biceps muscle of the arm when 'curling a weight'.

Eccentric Action

Here the muscle develops its active tension whilst it is being lengthened by stretching. One example of this is seen in the quadriceps muscle at the front of the thigh when walking or running down steps or down hill. Another is seen in the biceps of the arms as they control the lowering of a weight after a curl.

Static actions (*Isometric*)

These occur when the muscle is prevented from shortening whilst it is generating tension, as for example when straining against an immovable resistance. Even though the bones involved may not be moving, initially the sliding filament mechanism operates normally as the 'slack' in the elastic soft tissues is taken up, but once the steady state is achieved the cross bridges hold the filaments steady in one position.

Training & Performance Applications

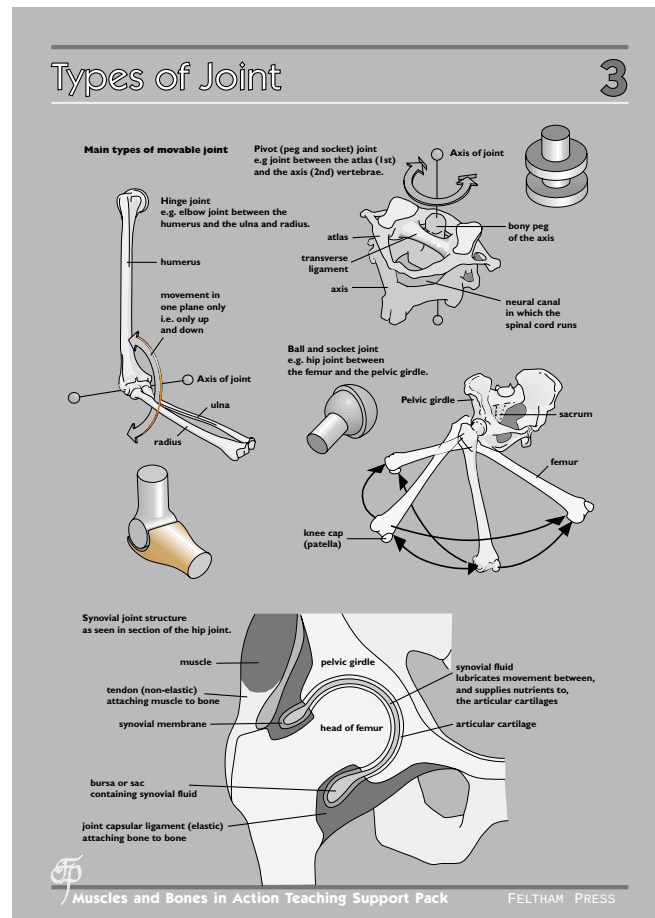
Isokinetic contractions occur when the muscle shortens at constant speed, and exerts maximum tension over the full range of movement at all joint angles, thus stimulating maximum gains over the whole range of joint movement. This is only fully achieved with specially designed weight training apparatus, which automatically adjusts the resistance to match the muscle force over the full range of movement. However, this constant movement over the whole range of joint movement is rarely met with in sport. The closest natural example of such isokinetic contraction in sport, is seen in the freestyle swimming armstroke.

Resistance or weight machines are safe to use, convenient, and popular in fitness centres; however free weights are preferred by weight lifters as they involve more muscle groups in more dynamic actions.

A training method known as **plyometrics** uses both concentric and eccentric contractions. In plyometrics, maximum concentric effort is made immediately following an eccentric phase, in which the muscles have been stretched whilst developing tension. Muscles contract with greater force as a result of the stretch reflex being stimulated to help recruit extra motor units. This is further reinforced by passive elastic recoil of the muscle, when the muscle is extended beyond its resting length, before being stimulated to contract. In this way muscles generate what can be referred to as explosive power. This is achieved for example by bounding and hopping, and is widely used by athletes wishing to increase their leg power.

Types of Joint

Image 3



Types of Joint

A joint is where two or more bones meet (*articulate*). There are three main types of joint found throughout the body.

Immovable Joints

In these the bones are fused together for strength, and no movement occurs between them, for example between the bones of the skull protecting the brain.

Slightly Movable Joints

In these a small amount of movement can occur, eg. the bones at the front of the pelvic girdle are held together by tough fibres that allow some movement, and can be a source of injury in people involved in physical activities.

Movable Joints

Most joints are freely movable, and these all share features which prevent friction between the moving bones. One of the main features is the presence of a fluid (*synovial fluid*) between the moving bones. These joints are therefore also called **synovial** joints. The bones are held together by slightly elastic fibres known as ligaments, which allow the bones to move; any damage to the ligaments results in the joint involved losing strength and stability, as is often seen in footballers knees.

There are two main examples of movable synovial joints.

Hinge Joint

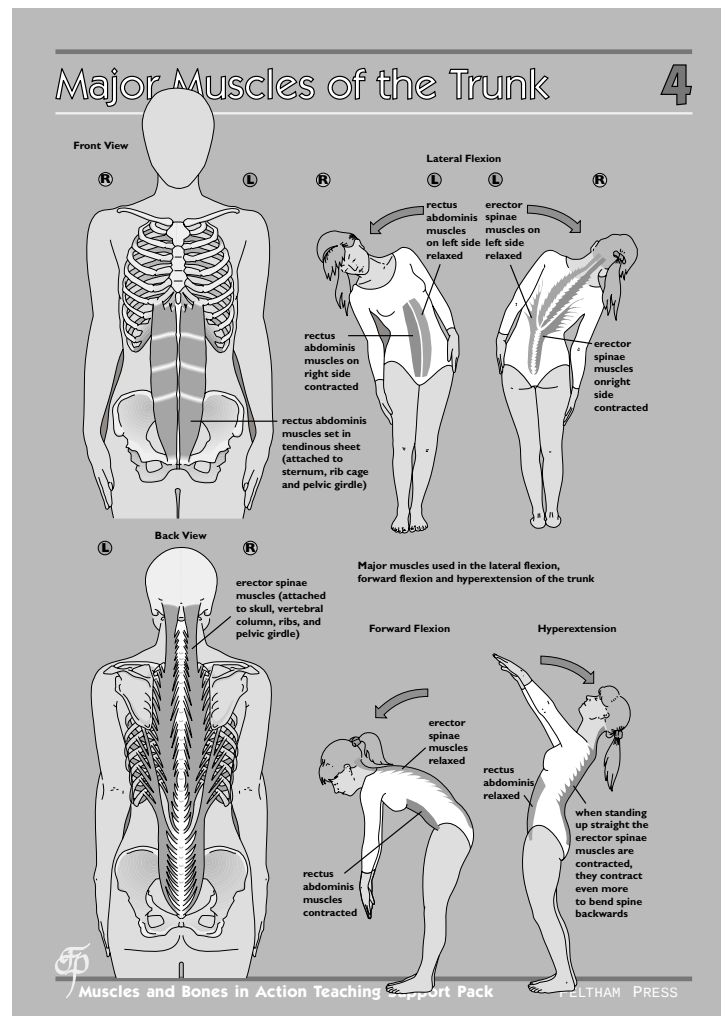
The elbows and knees are examples of hinge joints, where movement occurs only in one plane.

Ball and Socket Joint

The shoulders and the hips are examples of ball and socket joints, where movement occurs in more than one plane.

Major Muscles of the Trunk

Image 4



Thoracic Region

In movements of the trunk there is minimum movement of the thoracic vertebrae, which form part of the protective thoracic cavity.

Lumbar Region

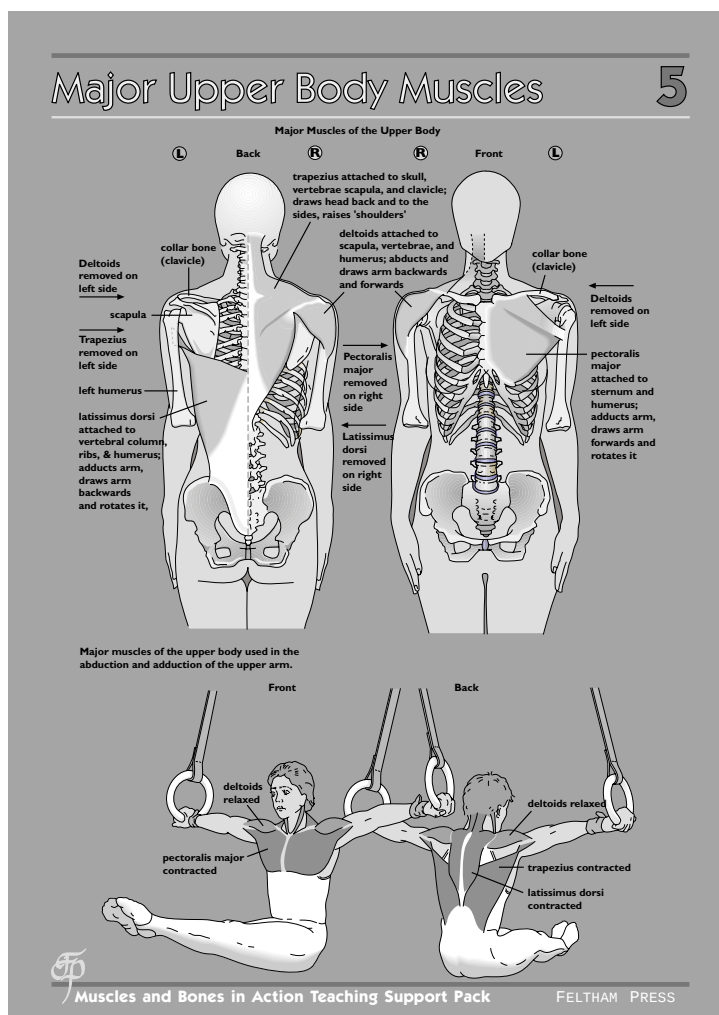
The lower lumbar region is notorious for its involvement in 'back' pain, frequently as a result of a 'slipped disc' when one or more of the fibro-cartilage discs between the lumbar vertebrae ruptures and/or becomes displaced and impinges on nerves - particularly the sciatic nerves which originate in this region and run the whole length of each leg. Excess mobility in this area may not be such a good thing, and there is something to be said for the old adage that "the answer for a bad back is a good front", which also reminds us of the principle of antagonistic sets of muscles (*not necessarily pairs*).

Inter-vertebral Discs

The intervertebral discs account for at least 25% of the length of the healthy, mature vertebral column. Their shrinkage with age explains a good part of age-related height loss. The discs are also compressed throughout periods of vertical posture (*standing or sitting*) and decompress in horizontal periods; thus with a 'normal' lifestyle we are taller in the mornings than we are in the evenings.

Abduction & Adduction of arms

Image 5

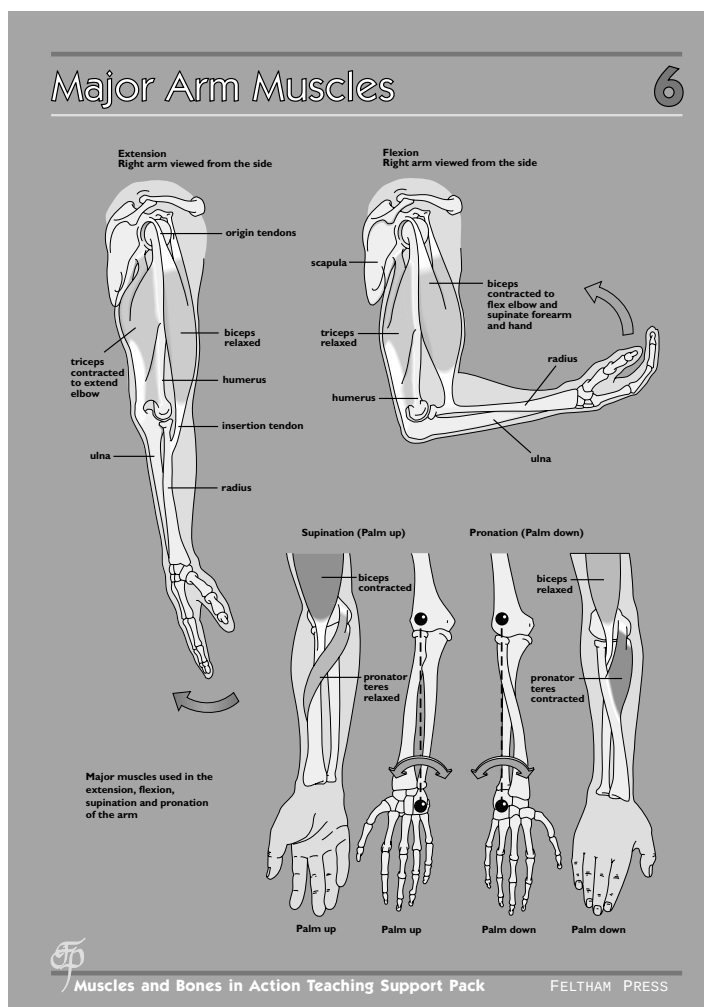


Shoulder Joint Stability The muscles shown and others in the same region play a major part in stabilizing the shoulder joint, which is notoriously unstable. The joint between the humerus and the glenoid cavity of the scapula is very shallow. This allows the great mobility of the arms, but equally contributes to its propensity for dislocation, especially anteriorly, where the head of the humerus is displaced to the front. This is a common injury in all contact sports, and once it has occurred there is a high risk (85%) of re-occurrence, the likelihood of which can be reduced by a regular programme of appropriate exercises to strengthen the muscles that stabilise the joint.

Other common injuries such as a broken collar bone and broken ligaments that normally bind the collar bone to the scapula, illustrate the 'propping' role of the collar bones, as the shoulder(s) sags forwards in these injuries, and the scapula(e) is/are displaced.

Major Muscles of the Arm

Image 6



Action of Gravity

The action of the biceps and triceps on the forearm is a clear illustration of the principle of antagonistic pairs of muscles, but in the vertical position it must be remembered that the arm will be straightened by the forearm falling under gravity, the triceps will not necessarily be involved. The action of the biceps on the forearm is also a clear example of the principle of bones as levers (*see below*).

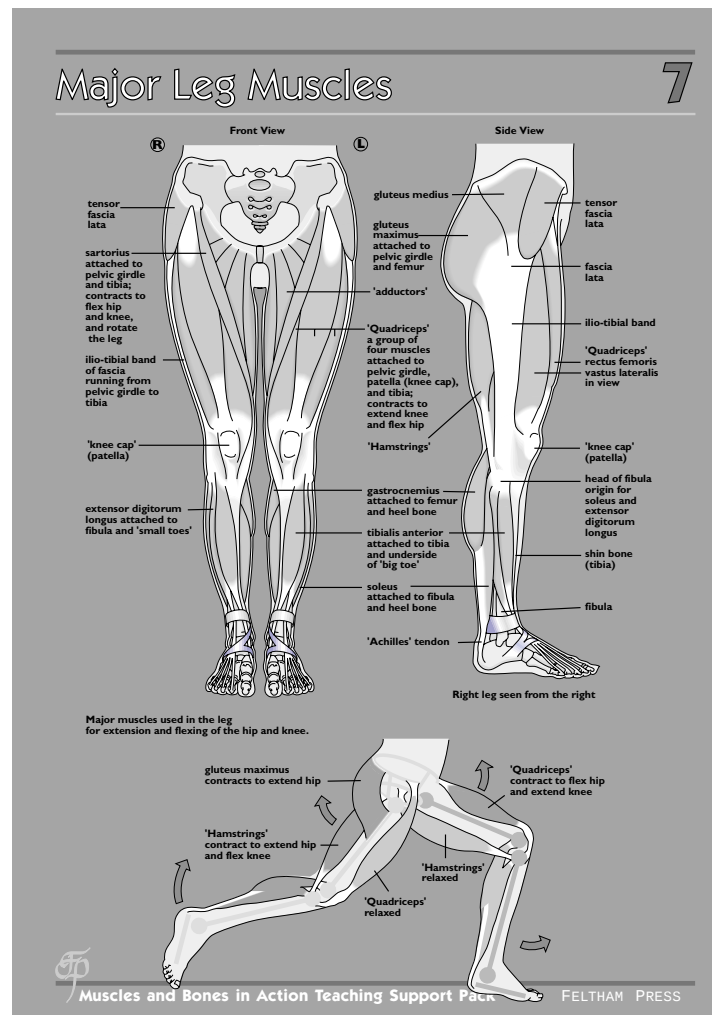
Dexterity

The great mobility of the arms, the rotatory movement of the forearm, and the ability to oppose (*touch*) the thumb with the tips of each finger of the same hand (*particularly the index finger*) are the anatomical basis of man's dexterity.

The arrangement of the major muscles which are involved in hand movements also aids dexterity. By being positioned in the forearm, with long tendons running down to their insertions on the hand bones, the bulk of the hand is kept to a minimum.

Major Muscles of the Legs

Image 7

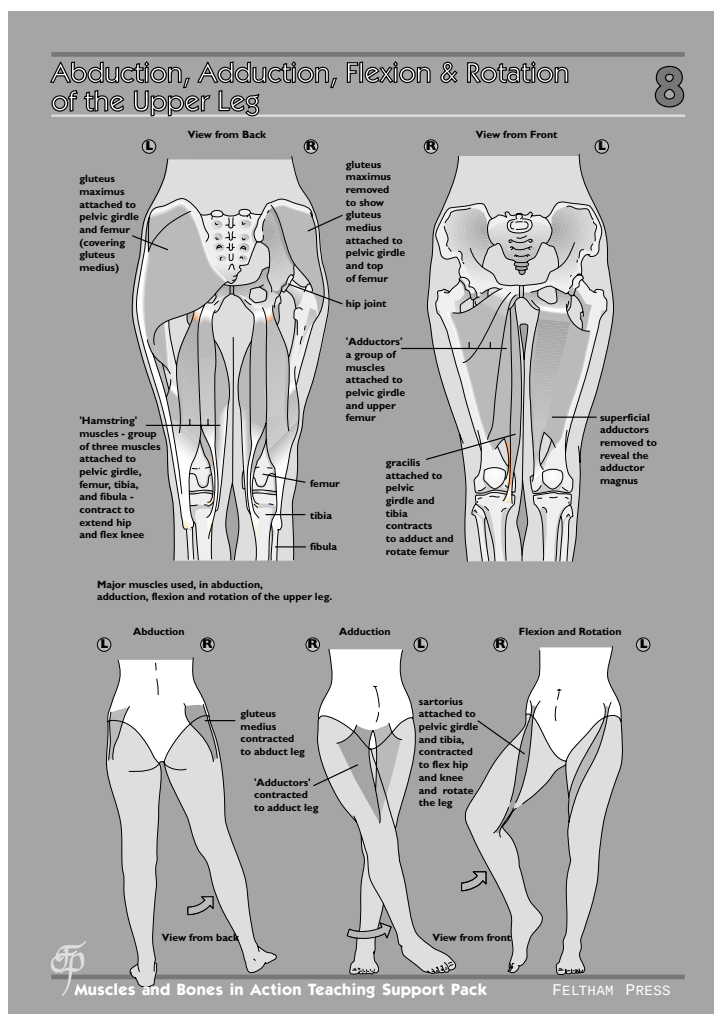


Uniquely Human

The well developed gluteus maximus and 'calf' muscles are characteristic of humans, reflecting as they do the demands of a truly upright posture, in which there is always a tendency to 'lean' forwards. In the 'calf', the soleus muscle is predominately composed of slow twitch muscle fibres and is particularly involved in stabilising balance in standing. The 'calf' also includes the gastrocnemius, and both are attached to the 'heel bone' via the 'Achilles' tendon.

Abduction, Adduction, Flexion & Rotation of the Upper Leg

Image 8

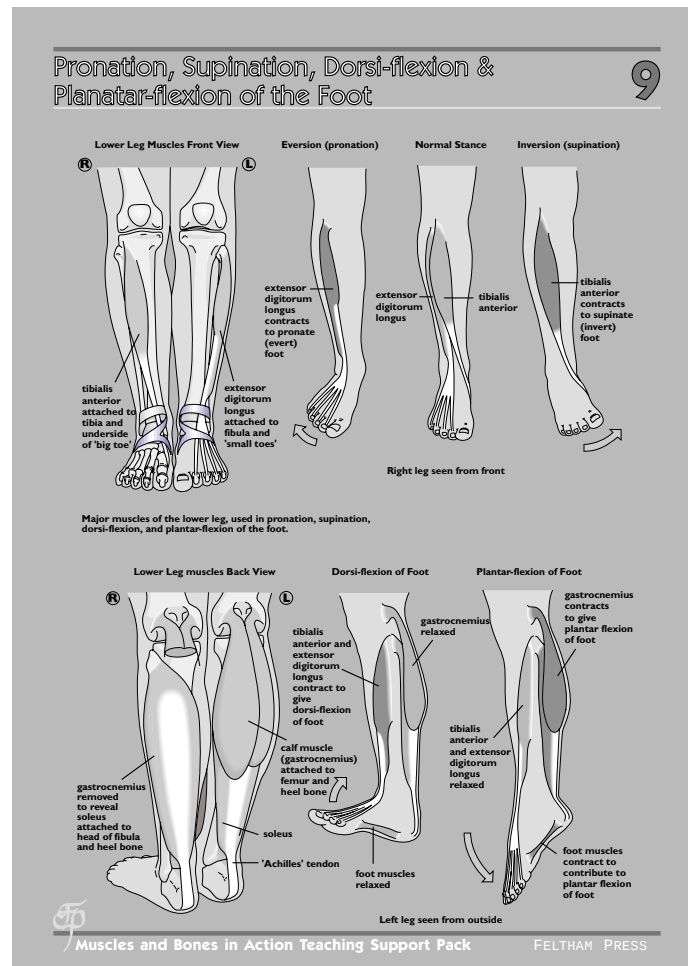


Weaker Movements

Compared to forward and back movements of the legs; rotation, abduction and adduction are relatively weak movements. However, in gymnastic style activities, special training will result in exceptional strength and mobility in all planes of joint movement. The sartorius is particularly involved in the action of 'crossing' one's legs (*hence its common name of the 'tailor's' muscle*), it is also the longest muscle in the body.

Pronation, Supination, Dorsi-flexion & Plantar-flexion of the Foot

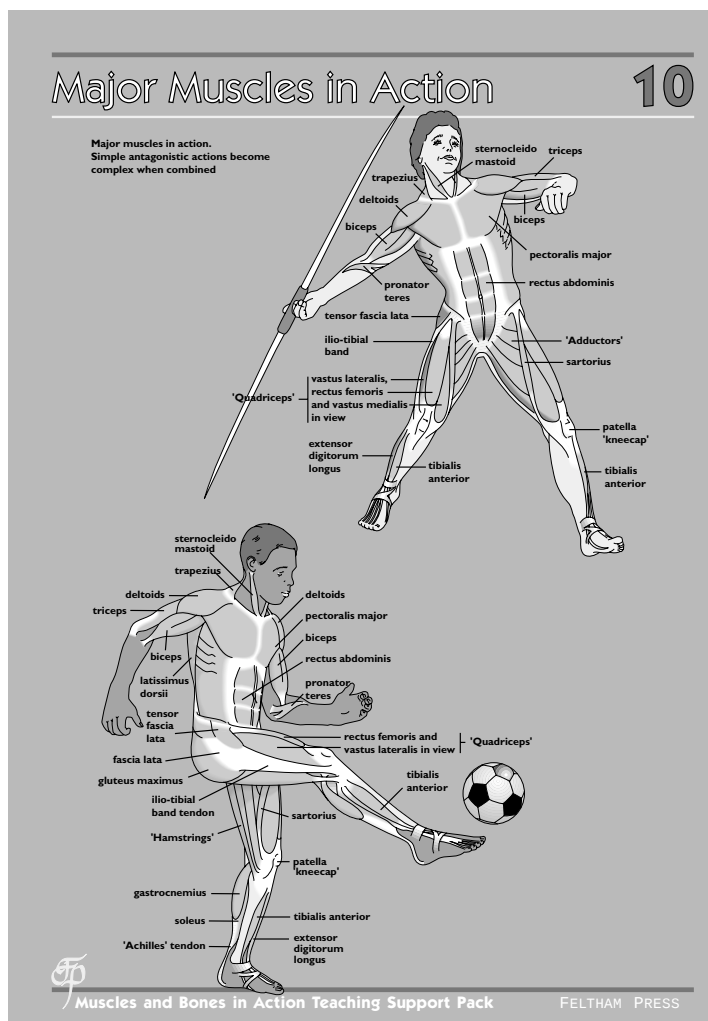
Image 9



Ankle & Foot Movement Over-pronation (*eversion*) and over-supination (*inversion*) are common problems amongst runners, often causing compensation injuries as the effects displace up the leg(s). Careful attention to footwear including individually prescribed orthotics can be very successful. However, much running shoe design is stylistic and very little to do with correct footfall. Claims of 'cushioning' of the 'heel-strike' ignore the fact that it is virtually impossible to land on the heel when running. Excessive wear at the heel of a running shoe is actually an indication that excess material has been getting in the way of correct footfall, rather than proving the worth of a design to cushion 'heel-strike'. The normal foot is a highly flexible structure, the action of which is not helped by being enclosed in a thick soled 'box'. Interference with correct natural action upsets the complex mechanism of muscles, tendons, and ligaments within the sole of the foot. Many of the so-called Achilles heel and 'calf' muscle problems of athletes are often symptoms of injury to foot muscles, tendons, and/or ligaments due to poor, restrictive, shoe design.

Major Muscles in Action

Image 10



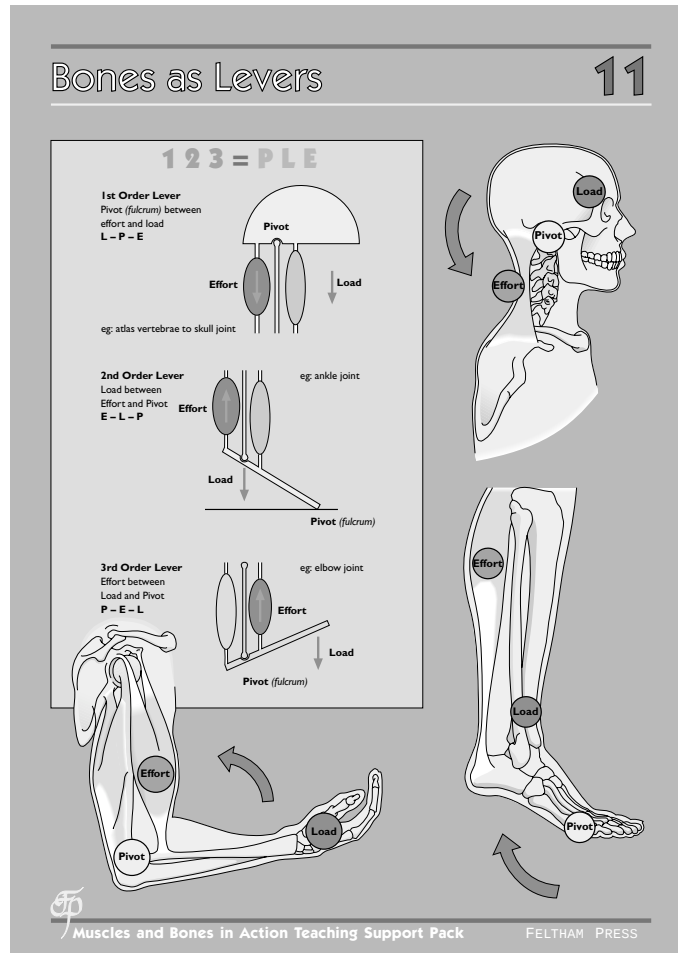
When confronted with the complex whole body movements seen in active sports, it is more difficult to analyse the coordination of contractions and relaxations in all the interacting muscles. However, if component movements are analysed, eg a throwing movement, or a kicking movement, the actions of antagonistic pairs or sets of muscles can be seen in context. Attempts can then be made to consider the interaction of all the superficial muscles involved in these actions, particularly those involved in counterbalancing and stabilising the action.

Table of Major Muscles and their Actions

MUSCLE	ACTION	EXERCISE
Adductor longus	Adducts and rotates leg.	Forcing legs together.
Biceps brachii	Flexes elbow. Adducts arm Supinates forearm & hand.	Curling, chinning.
Deltoids	Raise arm to shoulder level. Helps overhead movement.	Forward, lateral & back arm raises, overhead lifting.
Erector spinae	Holds spine erect (<i>extension</i>)	Standing up straight, raising arms and shoulders while lying prone (<i>on front</i>).
Gastrocnemius	Plantar flexion of foot, helps flex knee.	Rising onto tiptoe, as in running and jumping.
Gluteus maximus	Extends thigh & rotates it outwards.	Knee bending movements ie. squats, stair climbing, cycling.
'Hamstrings'	A group of muscles which flex knee & extend hip.	Extending leg behind & flexing knee as in running.
Latissimus dorsi	Pulls arm downwards & backwards. Depresses shoulder girdle, bends trunk sideways.	Pull downs behind head, pressing movements.
Pectoralis major	Pulls arm forwards & inwards.	All pressing movements.
Quadriceps femoris	A group of muscles which extends knee & flexes hip.	Knee bends, leg raises.
Rectus abdominis	Flexion & lateral flexion of trunk.	Sit ups, side bends, leg raises.
Sartorius	Flexes knee, flexes hip & rotates thigh outwards.	Crossing legs whilst seated.
Soleus	Plantar flexion of foot.	Rising on tiptoe.
Sternocleido-mastoid	Pulls head forward & to side, rotates it.	Forward bridging, pushing on forehead.
Tibialis anterior	Dorsi-flexion, adduction & inversion of foot.	Running.
Trapezius	Draws head back & to sides, raises shoulders.	Shrugging, & all lifting overhead.
Triceps brachii	Extends elbow & draws it back.	Press ups, dips, all over head lifting.

Bones as Levers

Image 11



Bones as Levers

A lever is a structure that transmits a force from an effort to a resistive force (*load*), via a pivot point or fulcrum. The amount of effort needed to move a load depends on the load, the length of the lever, the position of the pivot point - which in turn determines the length of the effort 'arm' and load 'arm' of the lever, and the point of application of the effort. These same considerations determine the distance moved by the end of the load 'arm'.

The arms and legs are long levers which, as a result of the arrangement of the muscle attachments and joints, increase the range of movement produced by the contraction of the muscles. For example, the biceps is attached to the radius close to the joint, and although it can only shorten by about 8 cms, this results in the end of the arm moving about 64cms (*depending on the length of the arm*).

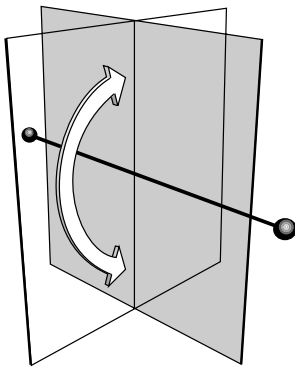
This arrangement, where the muscles produce a wide range of movement of the arms and legs, also means that our skeletal and muscle systems are working at a mechanical disadvantage.

Mechanical Disadvantage

Mechanical disadvantage means that the effort needed to move a load is greater than the load itself. This is illustrated by the fact that if you try to perform a biceps curl with a 10 kilogram weight, the biceps has to exert a force about 8 times greater than this. Generally it could be said that the human skeleton is built for range of movement rather than strength.

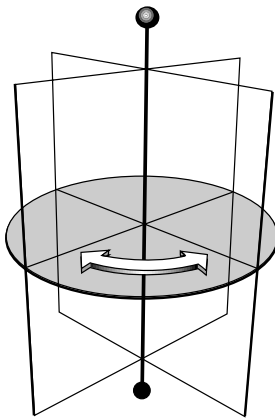
Movement in Relation to the Major Body Planes & Axes

Voluntary muscles exert their action via the skeleton, which acts as a series of levers, articulated at joints, which allow movement in all planes.



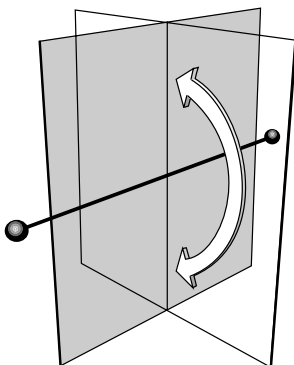
Front

Side to side (*transverse*) axis, involved in movement in the sagittal plane known as **flexion** and **extension**, eg. bending (*flexion*) and straightening (*extension*) the arm at the elbow.



Front

Vertical axis, involved in movement in a transverse plane known as **rotation**, eg. rotating the head from side to side.



Front

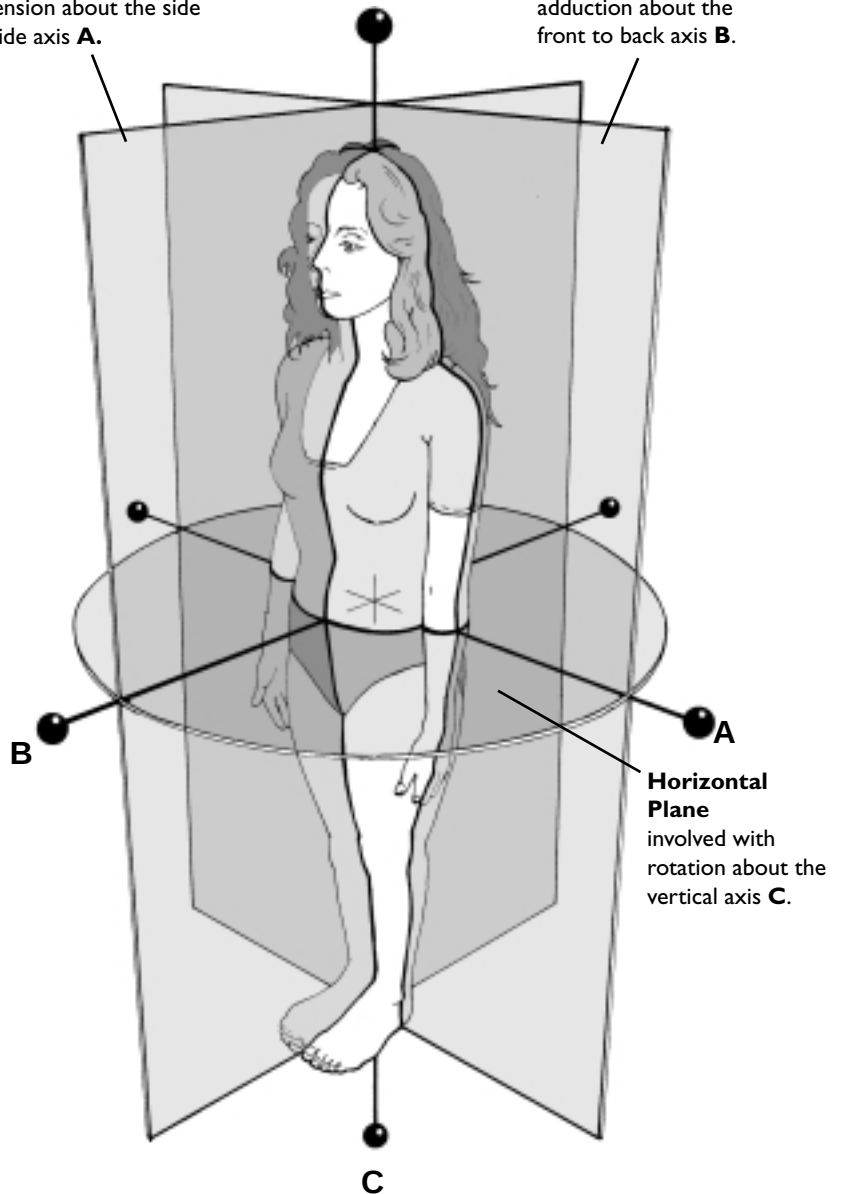
Front to back axis, involved in frontal (*coronal*) plane known as **abduction** and **adduction**, eg. raising the arms sideways at the shoulder (*abduction*), and lowering it (*adduction*).

Sagittal Plane

involved in flexion and extension about the side to side axis **A**.

Frontal Plane

involved in abduction and adduction about the front to back axis **B**.

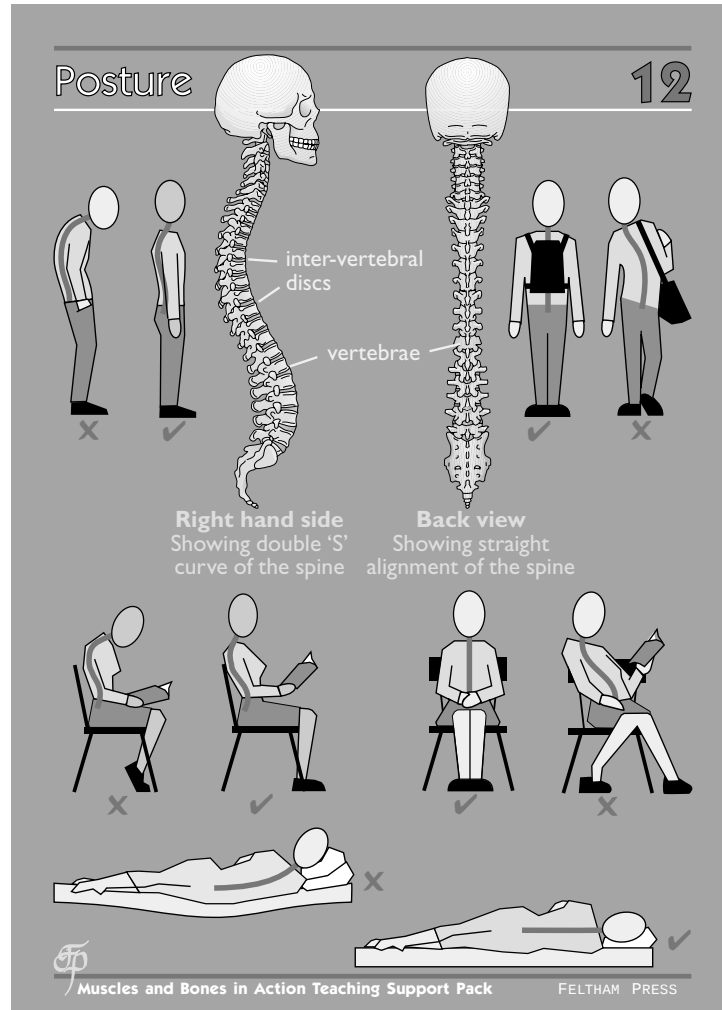


Horizontal Plane

involved with rotation about the vertical axis **C**.

Posture

Image 12



Correct Posture

Posture is about the way all the parts of the body are arranged (*aligned*) together. If any part is out of place (*misaligned*), it will affect the other parts, and could cause physical pain and injury. Poor posture could be caused by bone or joint defects, or uneven development of muscles.

Correct posture looks right, whether standing still or moving. If bad postural habits, develop these can lead to problems in the back, hips, and other parts of the body. Typical postural defects include round shoulders, uneven tilting of the hips, and abnormal curvature of the spine.

Some physical activities involve movements that can lead to poor posture. One example is the breast stroke in swimming, which tends to produce rounded shoulders after many years of intensive training.

It is important to lift correctly stand, sit, and sleep in ways which involve all the parts of the body being correctly aligned to each other.

It is perhaps curious that 'Good' posture does not appear to be a natural state in humans, but rather an 'ideal' to be strived for; although once again this may reflect the difficulties involved in true bipedalism.

Antagonistic Balance

Antagonistic balance can be analysed and practical measures can be taken to correct any imbalance. Imbalances between pairs of antagonistic balance can lead to a variety of musculo-skeletal problems including the very well known 'torn' or 'pulled' muscles.

Reciprocal inhibition of antagonistic pairs of muscles ensures that as the contracting muscle (*agonist*) exerts its force, the antagonistic muscle is inhibited from contracting and relaxes, thus allowing the contracting muscle to contract fully and correctly.

The dynamics of the interactions between muscles are very complex, and the causes of muscle damage are not always clear. However, if one member of a pair of antagonistic muscles is too strong compared to the other, then the weaker muscle could be 'torn' or 'pulled' as a result of initiating its contraction against the stronger which may not be so easily inhibited and may still be exerting a significant force.

The 'torn' or 'pulled' 'hamstrings' of sprinters and games players is perhaps the most well known example. Although the 'hamstrings' and the 'quadriceps' are each groups of muscles, for simplicity's sake they will be treated as a single pair of antagonistic muscles in these notes.

The operation of the 'hamstrings' and the 'quadriceps' across the knee and the hip joints, and the involvement of the muscles of the lower leg, and around the hip joint render any analysis of the running action extremely complex, but again for simplicity's sake only their role in the extension and flexion of the knee will be considered here.

The force production of each is measured on an isokinetic machine at three predetermined speeds.

Speed in degrees per second:

60
180
300

The recommended force production ratio between 'hamstrings' and 'quadriceps' (*i.e. Flexion/Extension ratio*) at the different speeds are shown below, at the faster speeds the 'hamstrings' become more efficient in relation to the 'quadriceps', hence the increased ratio at the faster speeds. In other words the force exerted by the 'quadriceps' decreases with increasing speed, and vice versa for the 'hamstrings'.

A wide sample of measurements has given rise to commonly agreed figures for the force production of many antagonistic pairs of muscles. The figures for the hamstrings and 'quadriceps' in the flexion of the knee are set out in the table.

Flexion/Extension Ratio

(multiplied by 100 to make whole numbers or to be quoted as a percentage)

Male	Female
61	62
72	76
78	79

For example if at a speed of 60 degrees per second a male subject was found to have:

'hamstring' force production = 122 N

'quadriceps' force production = 200 N

the **Flexion/Extension ratio = 61**

This would be considered to be good.

However, if another subject was found to have a Flexion/Extension ratio of less than 60, recommendations would be made for a training programme to strengthen the 'hamstrings' which would result in the Flexion/Extension Ratio being increased in the desired direction.

At the slow speed this would be strength work, eg. 3 x [8 x 80% - 90% maximum], and at the high speed it would be power work, eg. 3 x [20 seconds at 50% - 60% maximum]. If the imbalance was at the middle speed, then the recommendations would be a mixture of the two extremes. Obviously the situation is too complicated to be covered by simple equations such as these, and each individual case would have to be worked out carefully by physiologist, coach, and athlete; and kept under continual review. However, the measurements introduce a rational qualitative approach into an otherwise confusing situation based only on trial and error, and hearsay.

In some cases the 'quadriceps' are too weak, resulting in the Flexion/Extension Ratio being too great. This can give rise to hip problems, as a result of the 'quadriceps' action in the flexion of the hip.

It is also quite common for the Flexion/Extension Ratio to differ between the two legs of a single subject. In these cases single leg exercises would be undertaken to correct the imbalances if the differences are greater than about 10%.

Others have 'flat profiles' across the three speeds, for example a male athlete could have figures of 60, 64, and 68, for the respective speeds of 60, 180, and 300 degrees per second. This would indicate that the 'hamstrings' are not working efficiently at the higher speeds.

The 'hamstrings' are particularly prone to strains in sprinting as a result of initiating their contraction when at full stretch in opposition to the action of the powerful 'quadriceps'.

Joint	Speed Degrees per Second	Flexion/Extension Ratio	
		Male	Female
Elbow	60	97	88
	120	93	98
Wrist	60	57	57
	120	97	97
Ankle	60	31	43
	120	39	54
Shoulder	60	90	79

References:

- Davies, G.: *Compendium of Isokinetics in Clinical Usage and Rehabilitation Techniques (4th ed.)*, Onalaska, WI: S&S Publishers, 1992.
- Dvir, Z.: *Isokinetics: Muscle Testing, Interpretation and Clinical Applications*, Edinburgh, United Kingdom; Churchill Livingstone, 1995.
- Perrin, D.: *Isokinetic Exercise and Assessment*, Champaign, IL: Human Kinetics Publishers, 1993.

APPENDIX

Session Overhead Transparencies 1 - 12

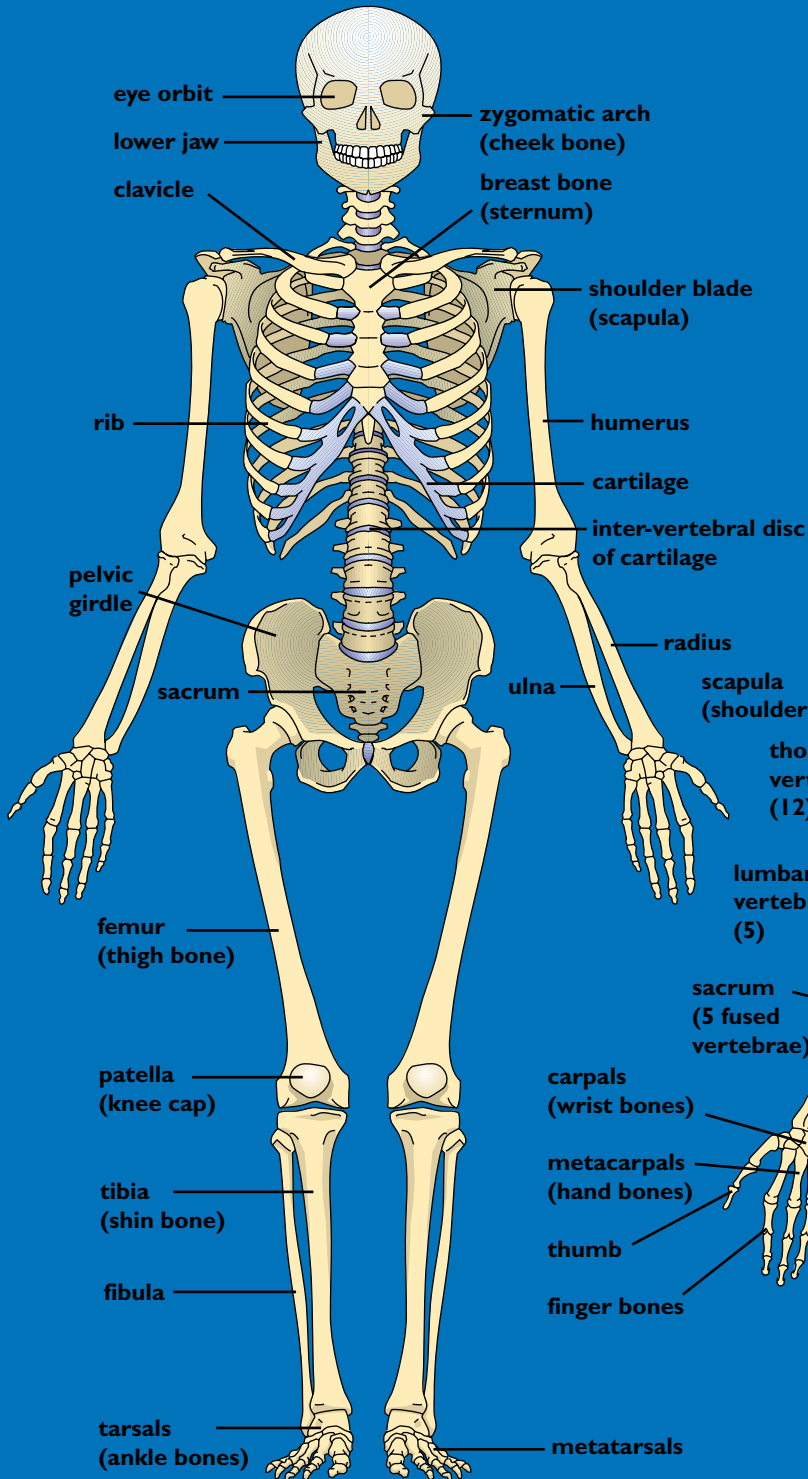
The Skeletal System

1

R

Skeleton from the Front

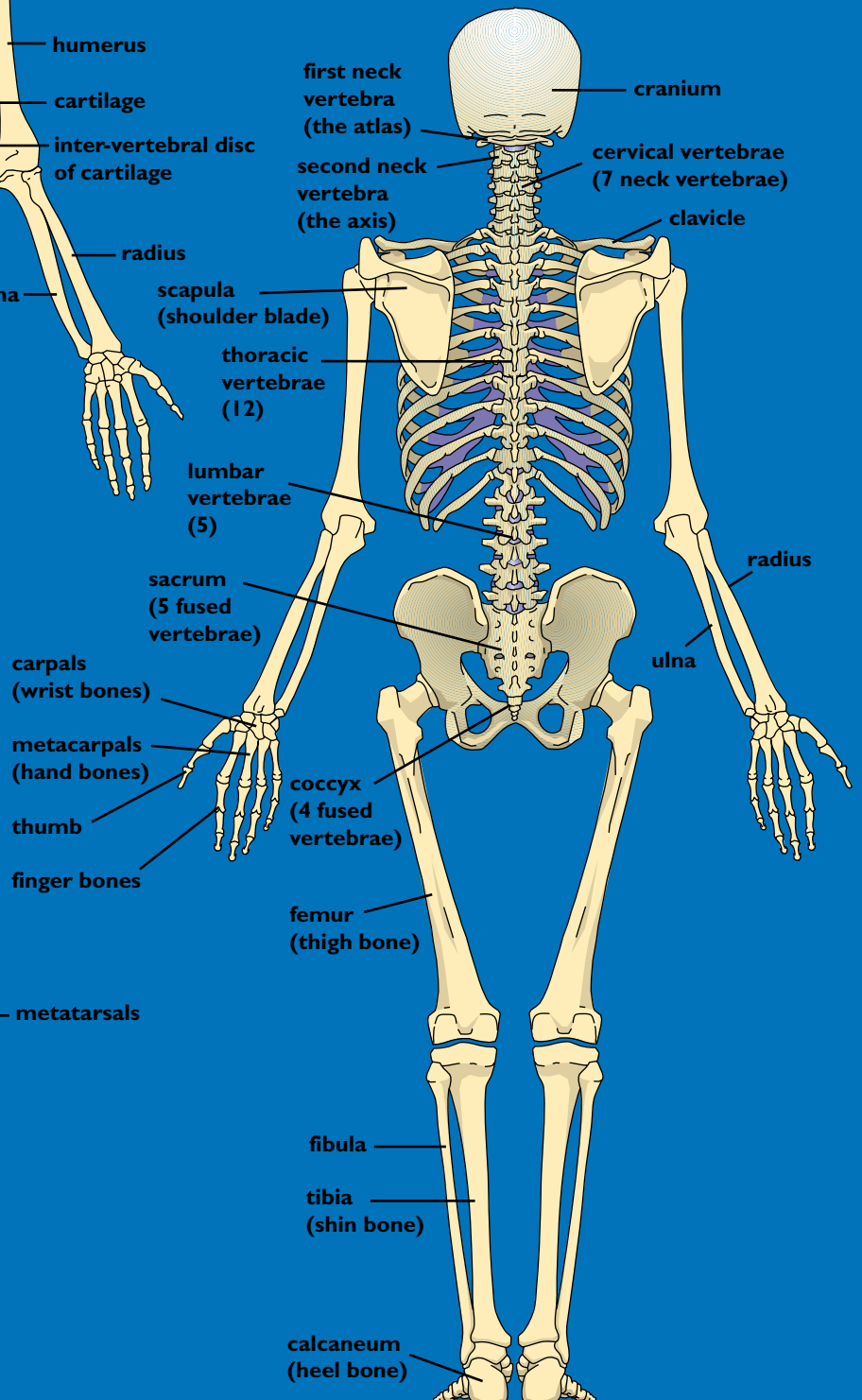
L



L

Skeleton from the Back

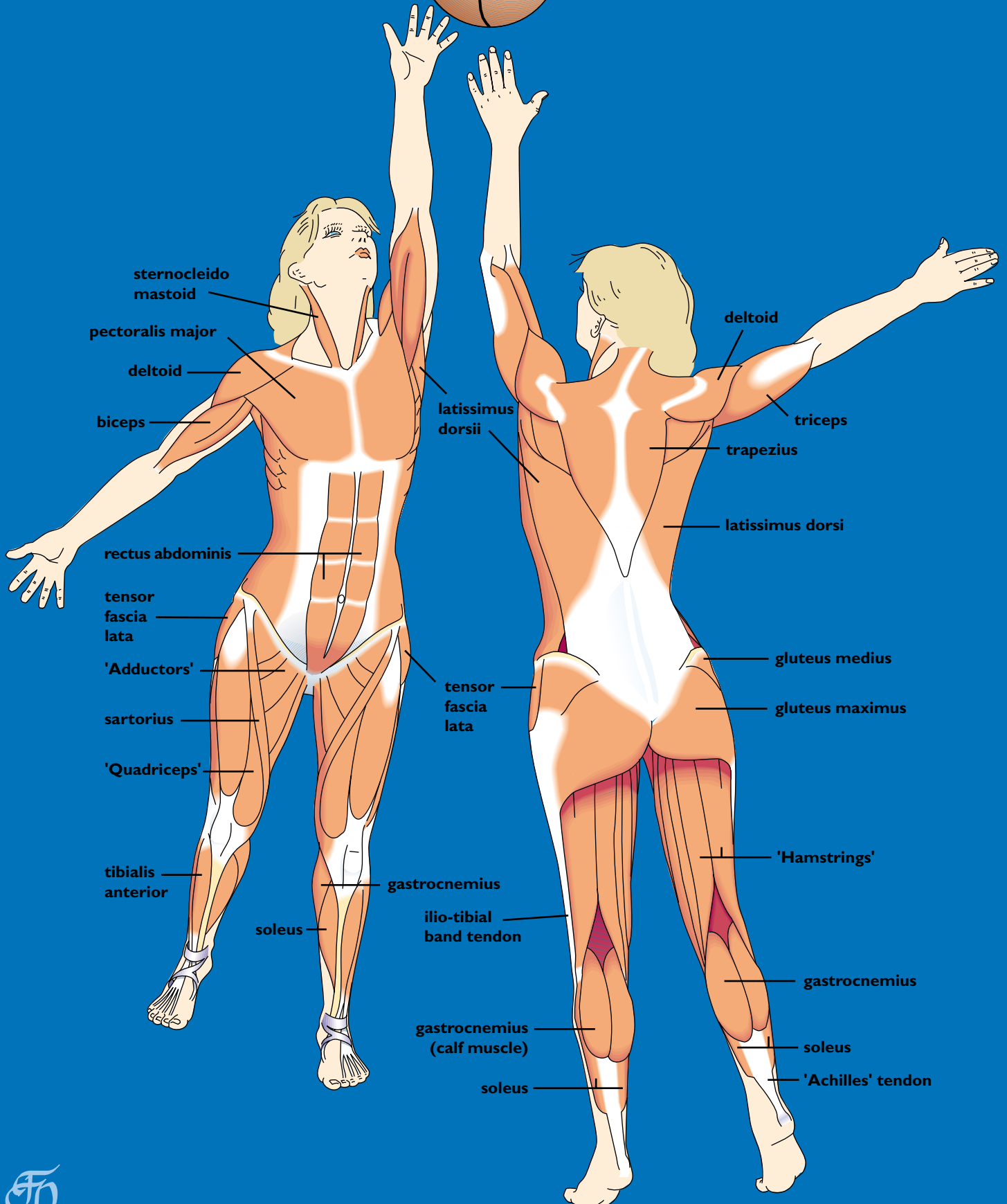
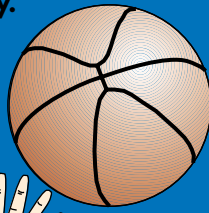
R



Muscular Arrangements

2

Superficial muscles of the human body.
Not all muscles are shown and
those that are have been simplified

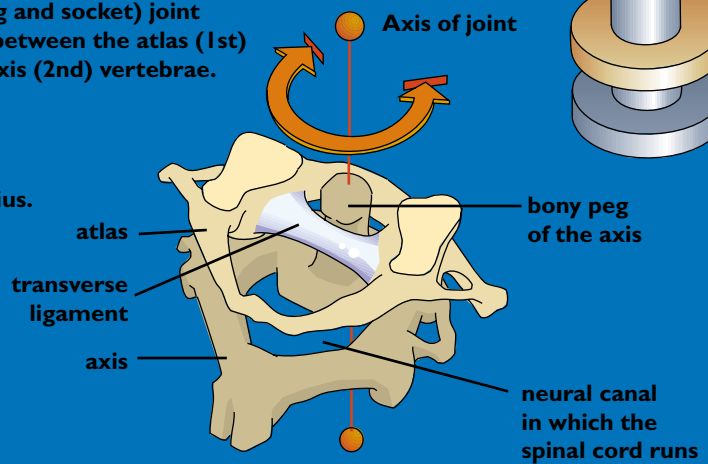
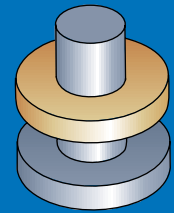


Types of Joint

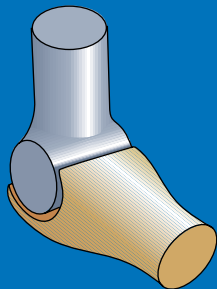
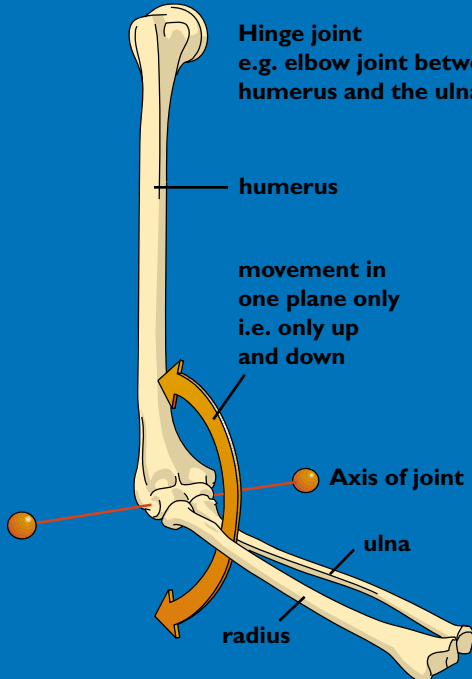
3

Main types of movable joint

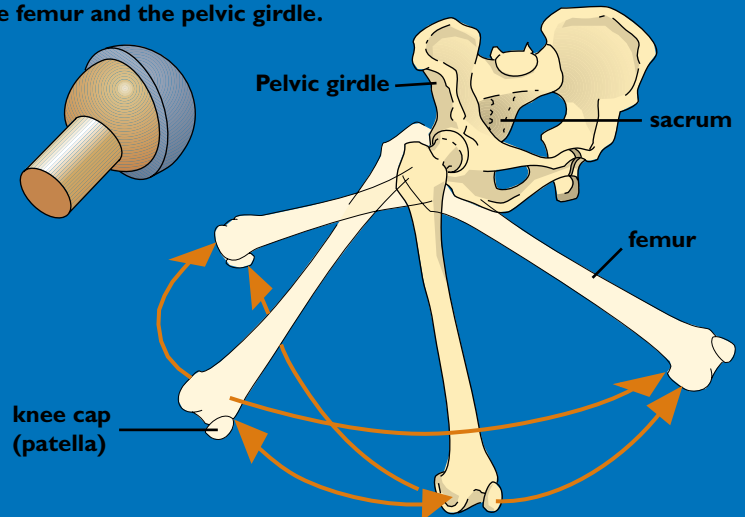
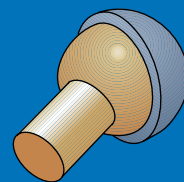
Pivot (peg and socket) joint
e.g joint between the atlas (1st) and the axis (2nd) vertebrae.



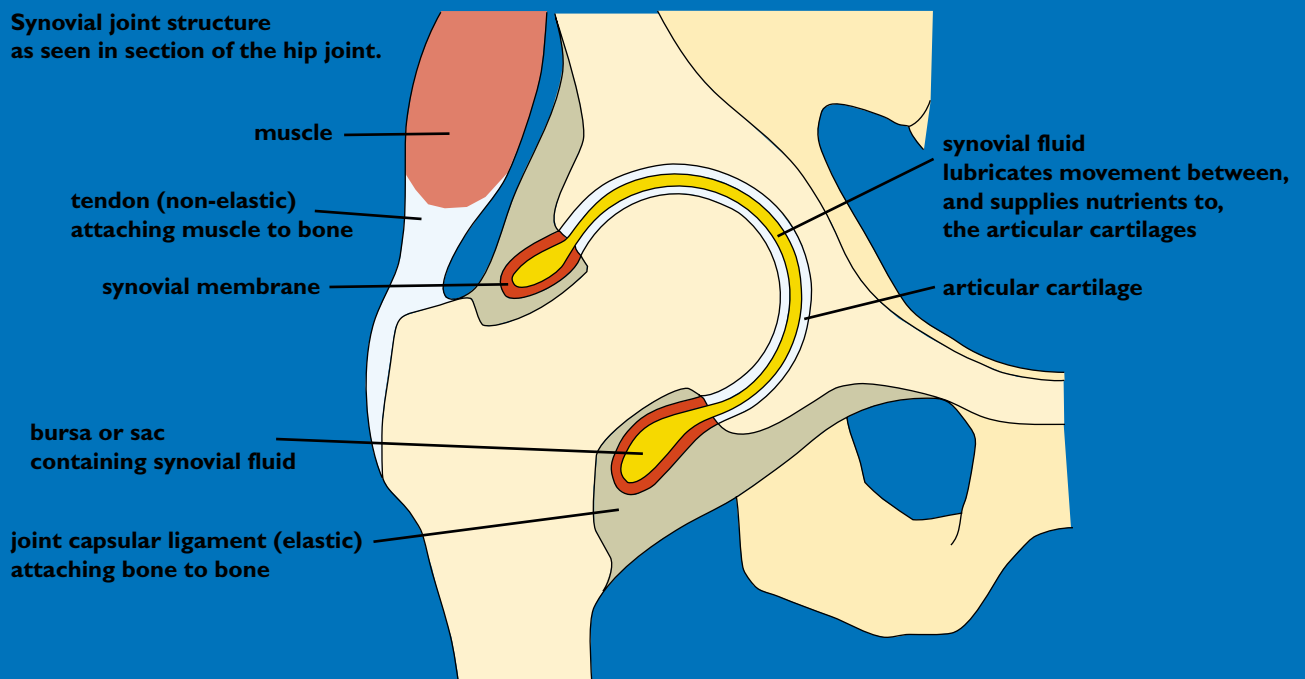
Hinge joint
e.g. elbow joint between the humerus and the ulna and radius.



Ball and socket joint
e.g. hip joint between the femur and the pelvic girdle.



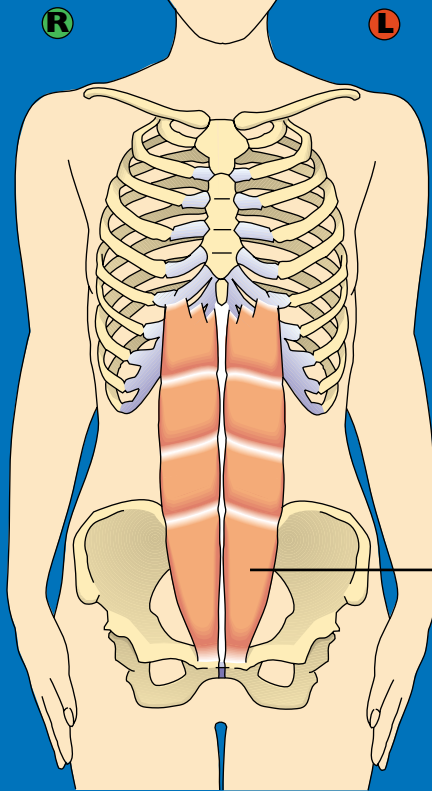
Synovial joint structure
as seen in section of the hip joint.



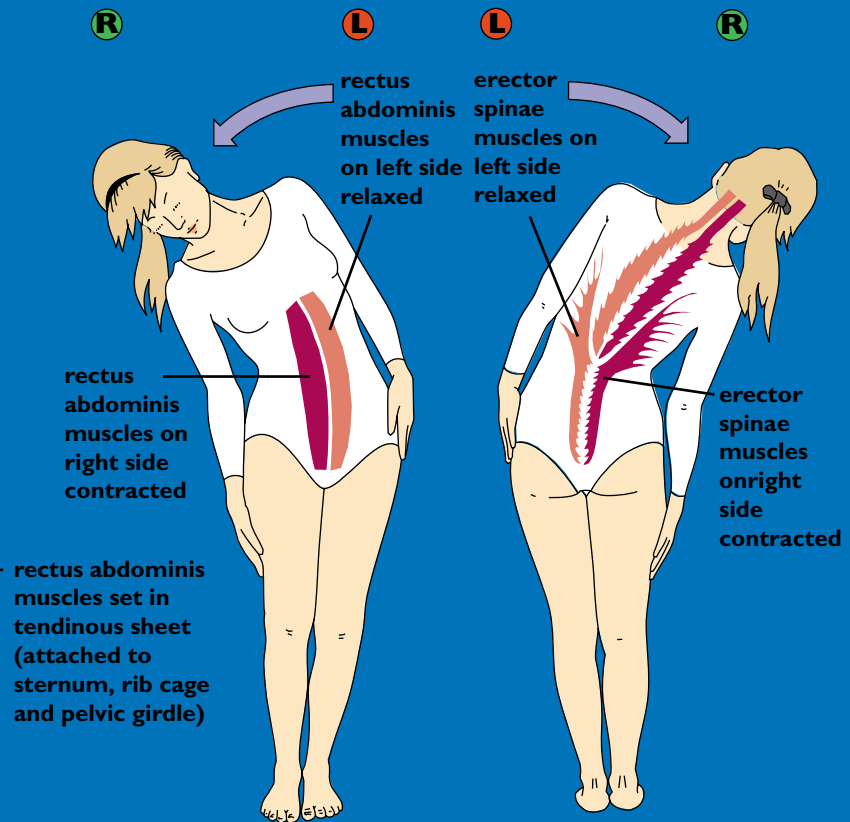
Major Muscles of the Trunk

4

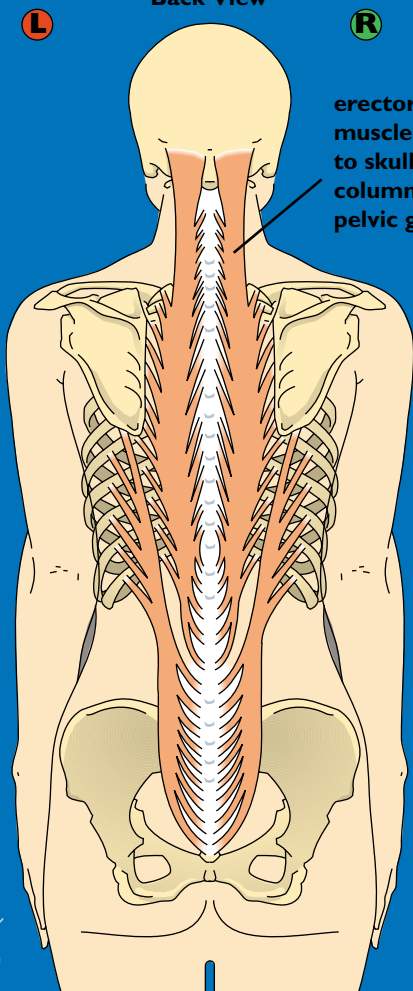
Front View



Lateral Flexion



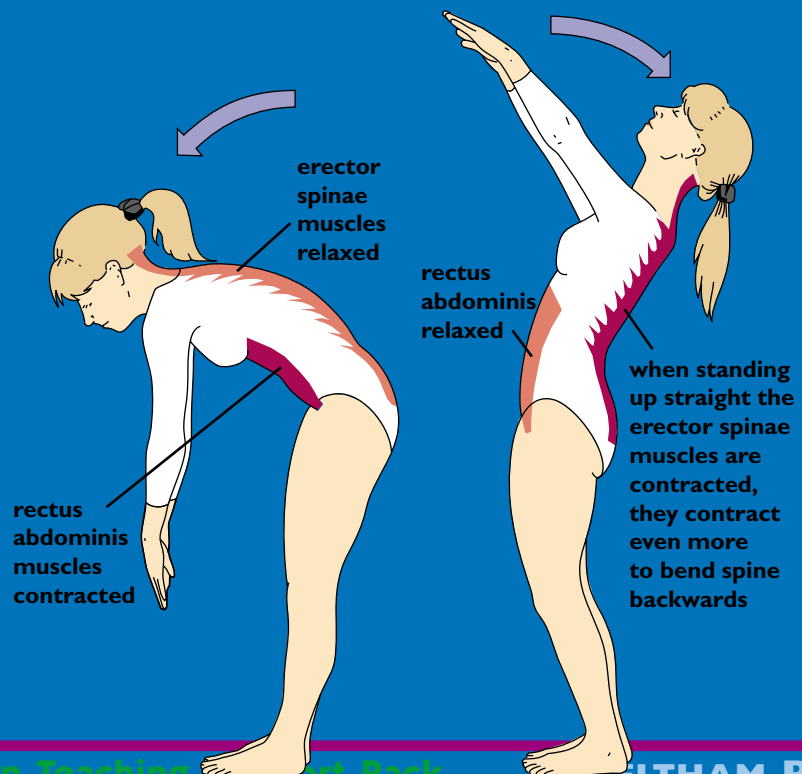
Back View



Major muscles used in the lateral flexion, forward flexion and hyperextension of the trunk

Forward Flexion

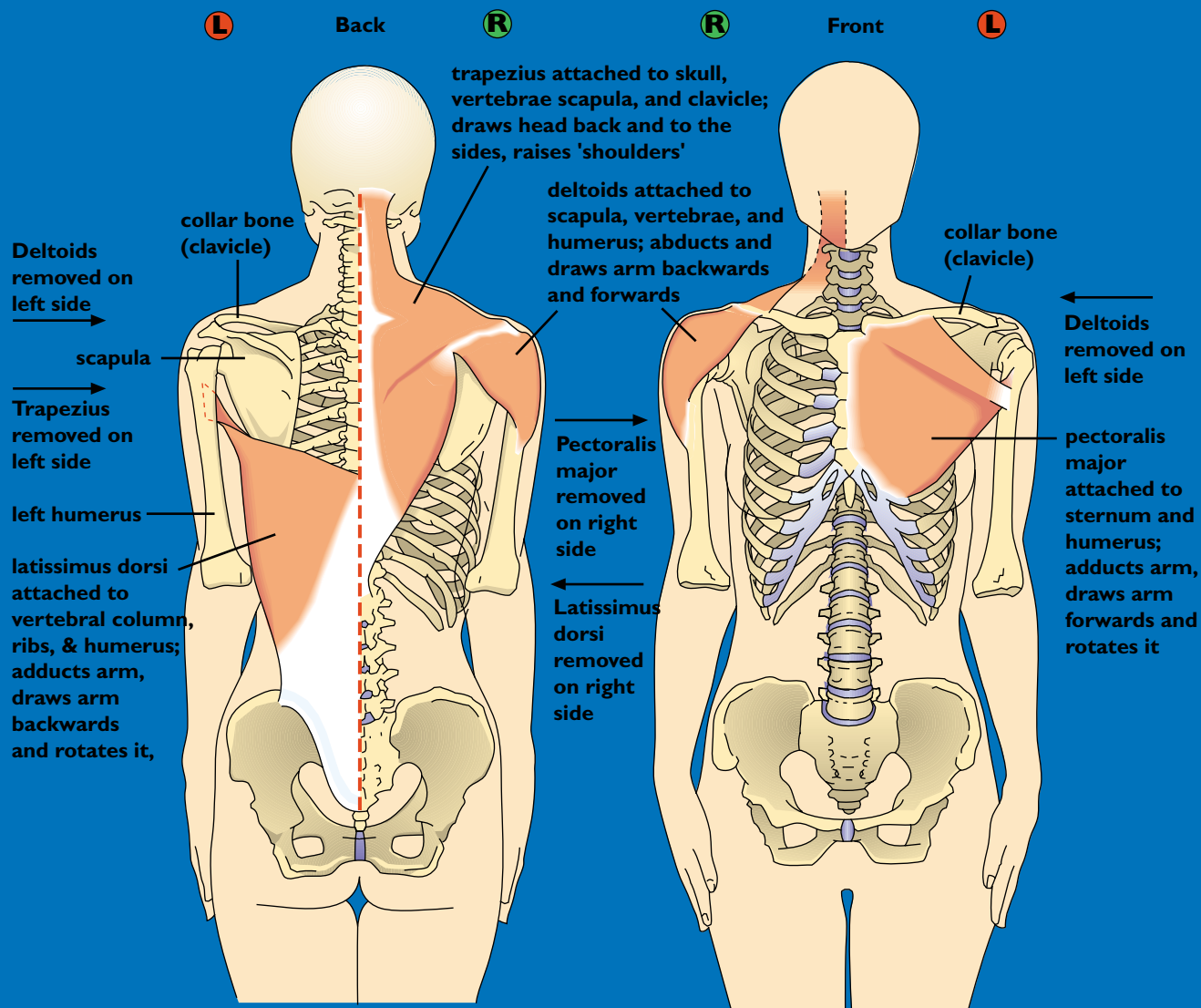
Hyperextension



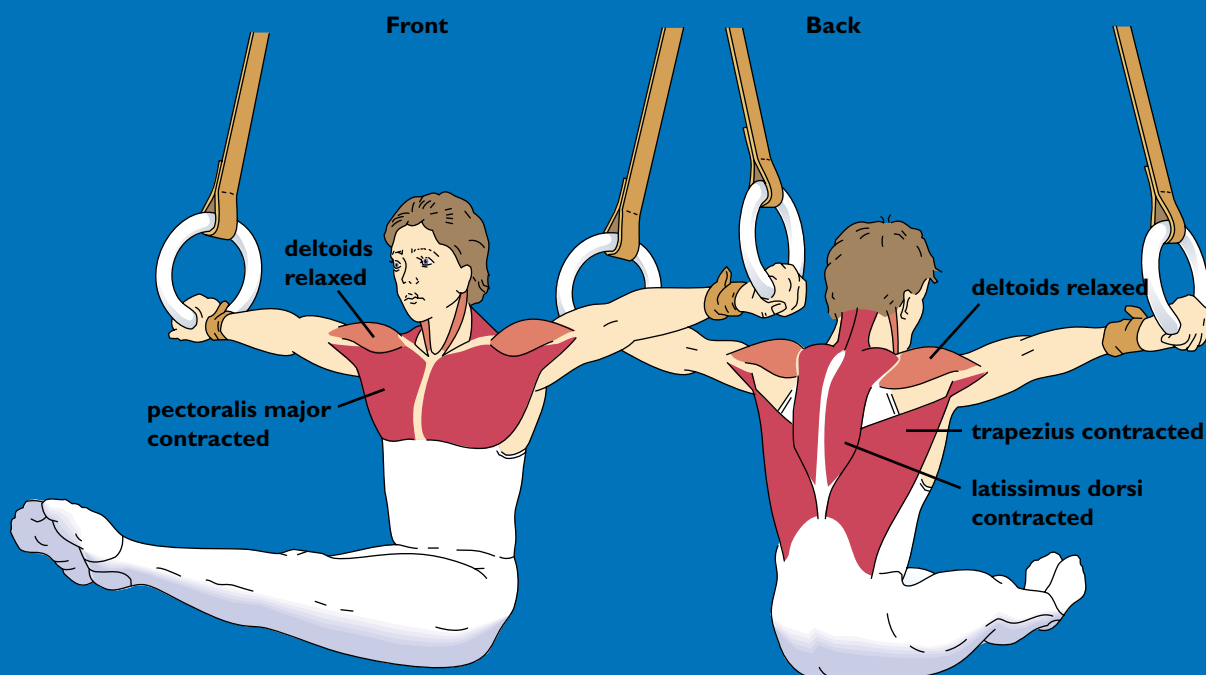
Major Upper Body Muscles

5

Major Muscles of the Upper Body



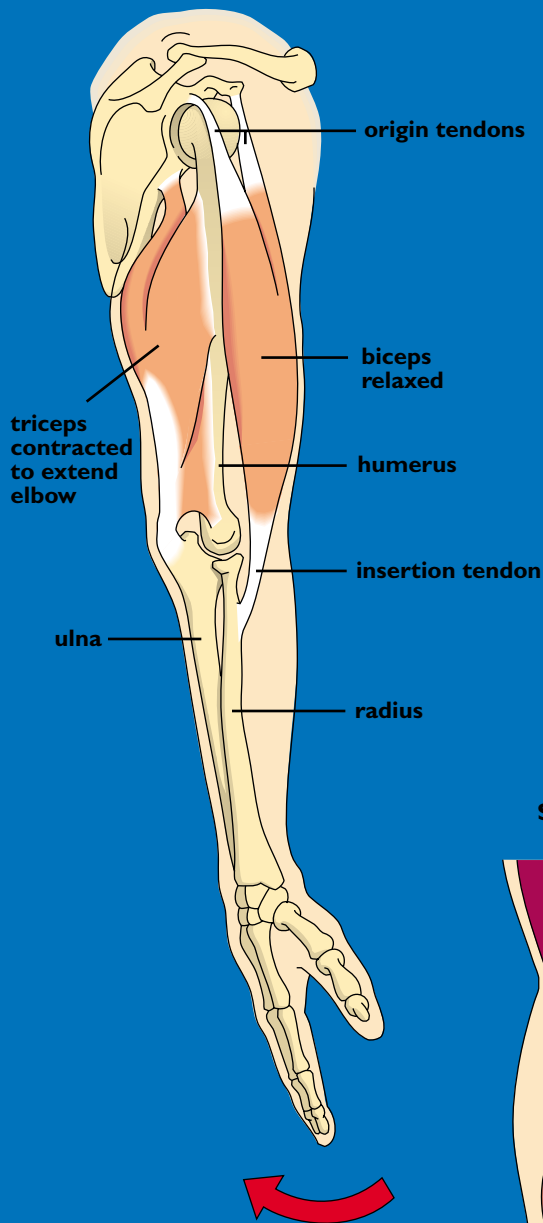
Major muscles of the upper body used in the abduction and adduction of the upper arm.



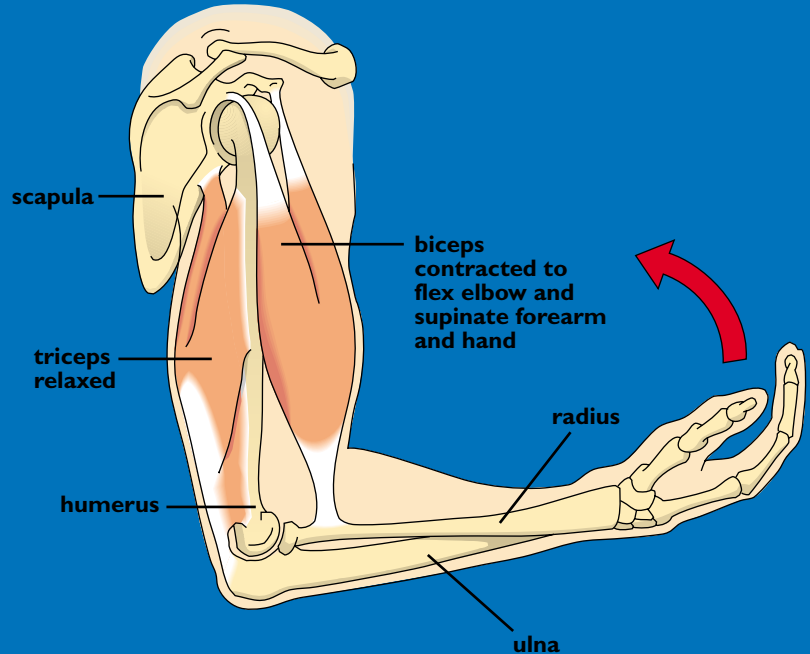
Major Arm Muscles

6

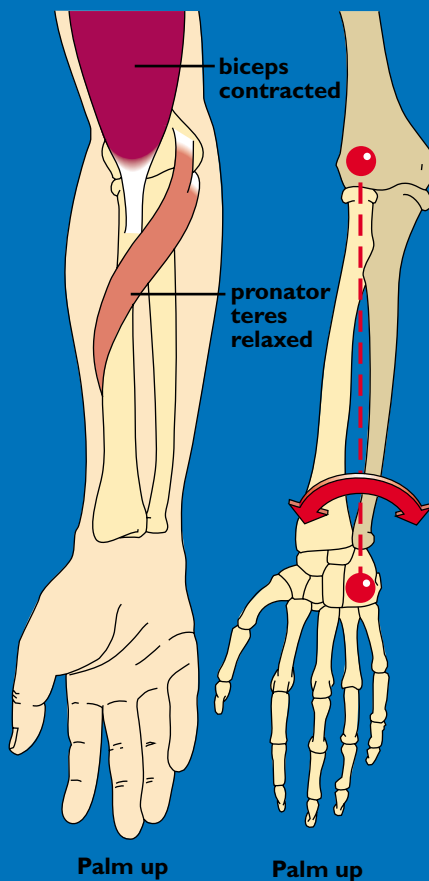
Extension
Right arm viewed from the side



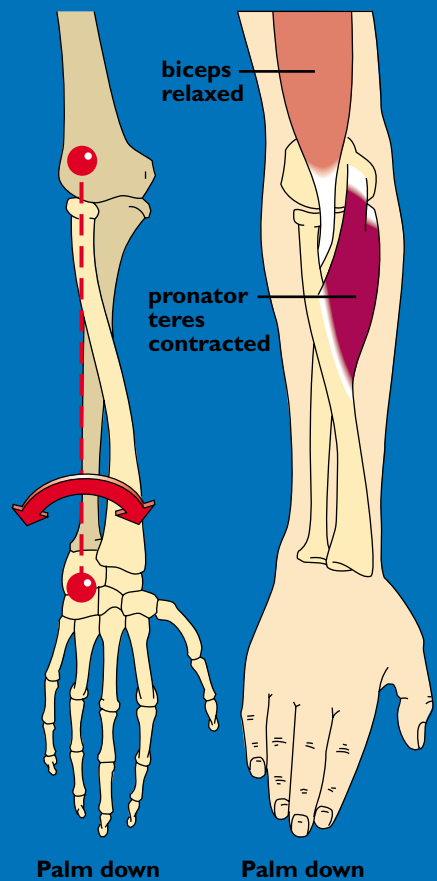
Flexion
Right arm viewed from the side



Supination (Palm up)



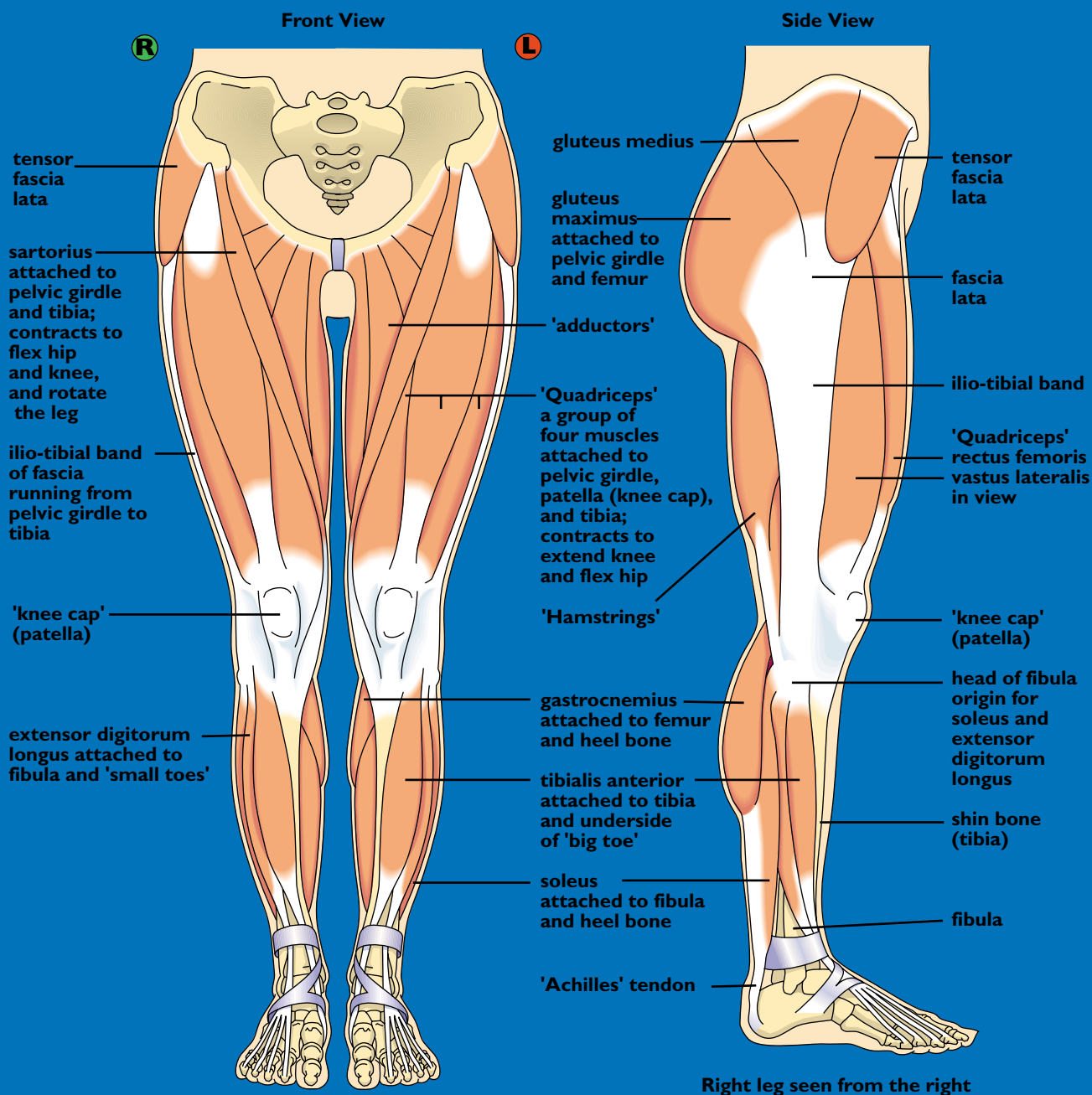
Pronation (Palm down)



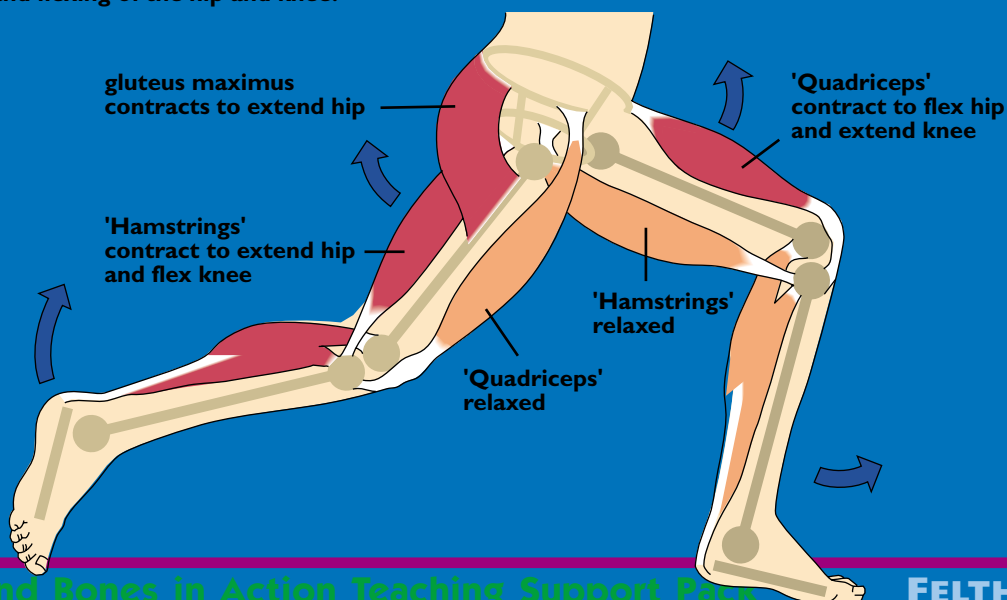
Major muscles used in the extension, flexion, supination and pronation of the arm

Major Leg Muscles

7

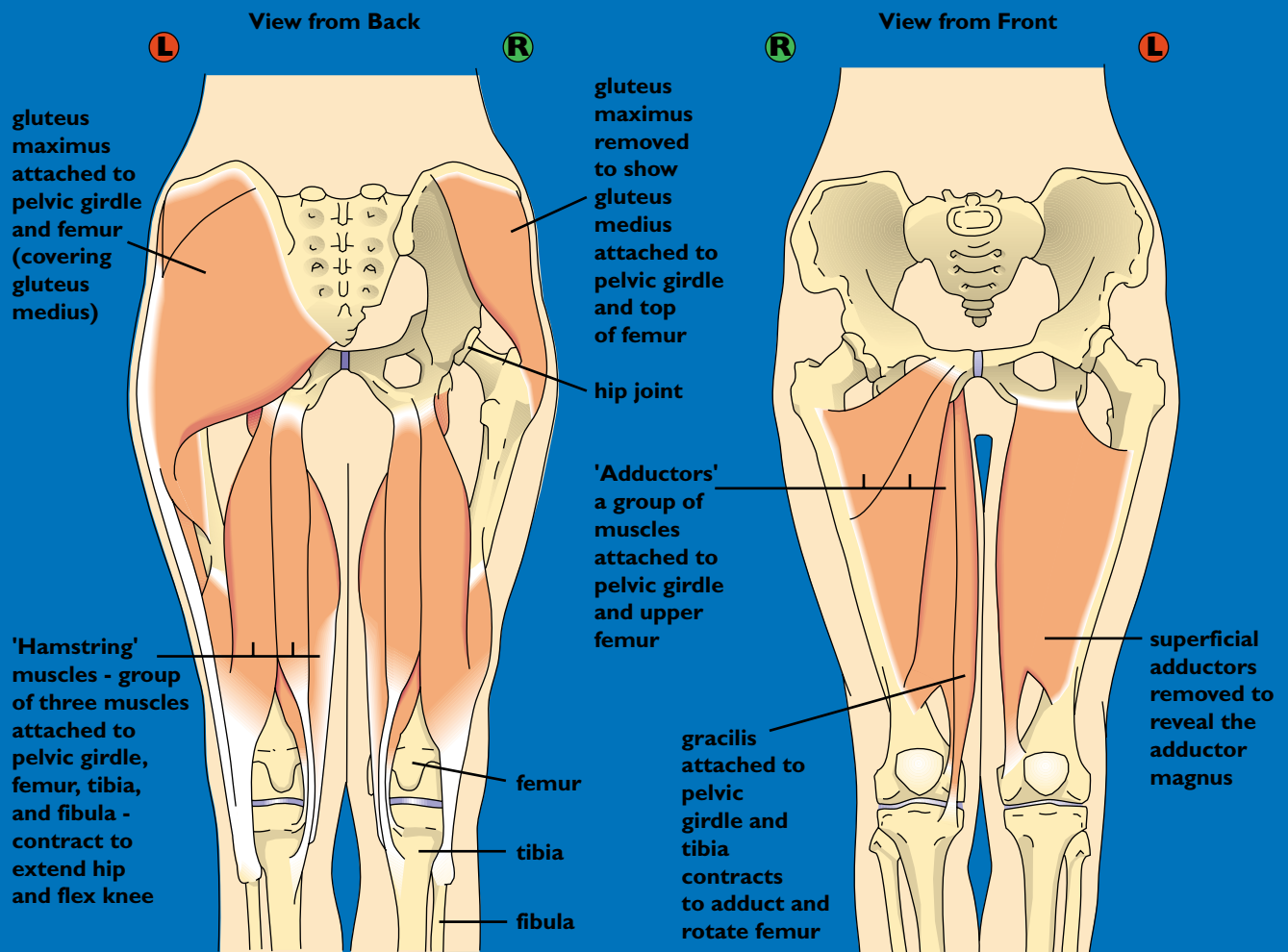


Major muscles used in the leg for extension and flexing of the hip and knee.

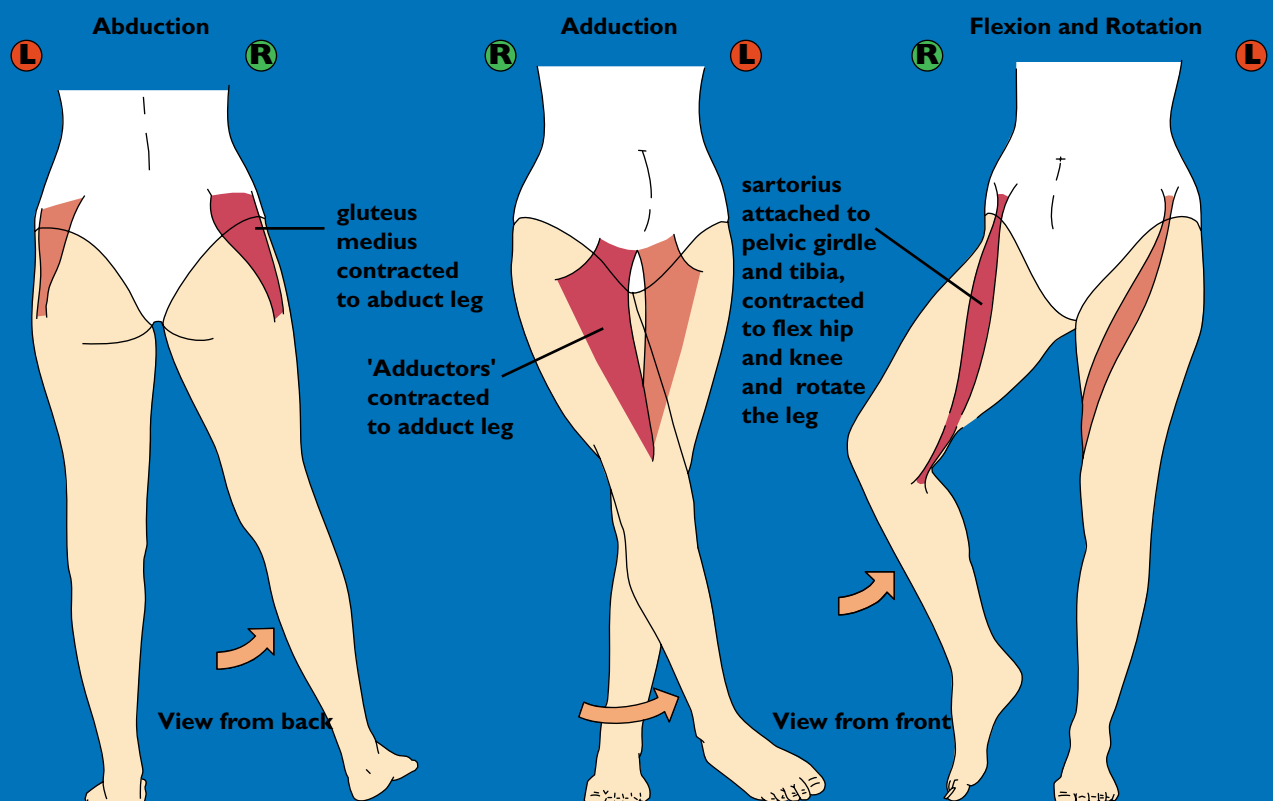


Abduction, Adduction, Flexion & Rotation of the Upper Leg

8

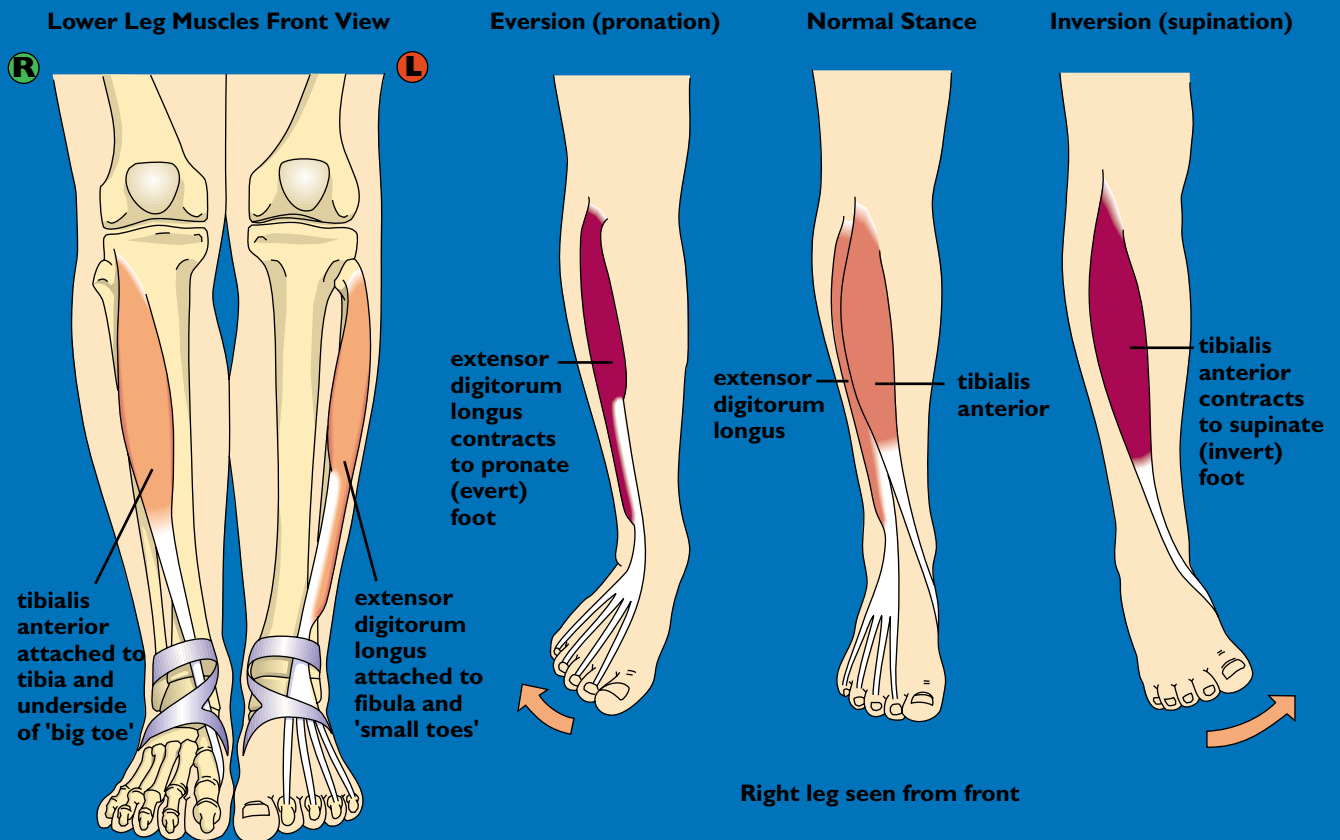


Major muscles used, in abduction, adduction, flexion and rotation of the upper leg.

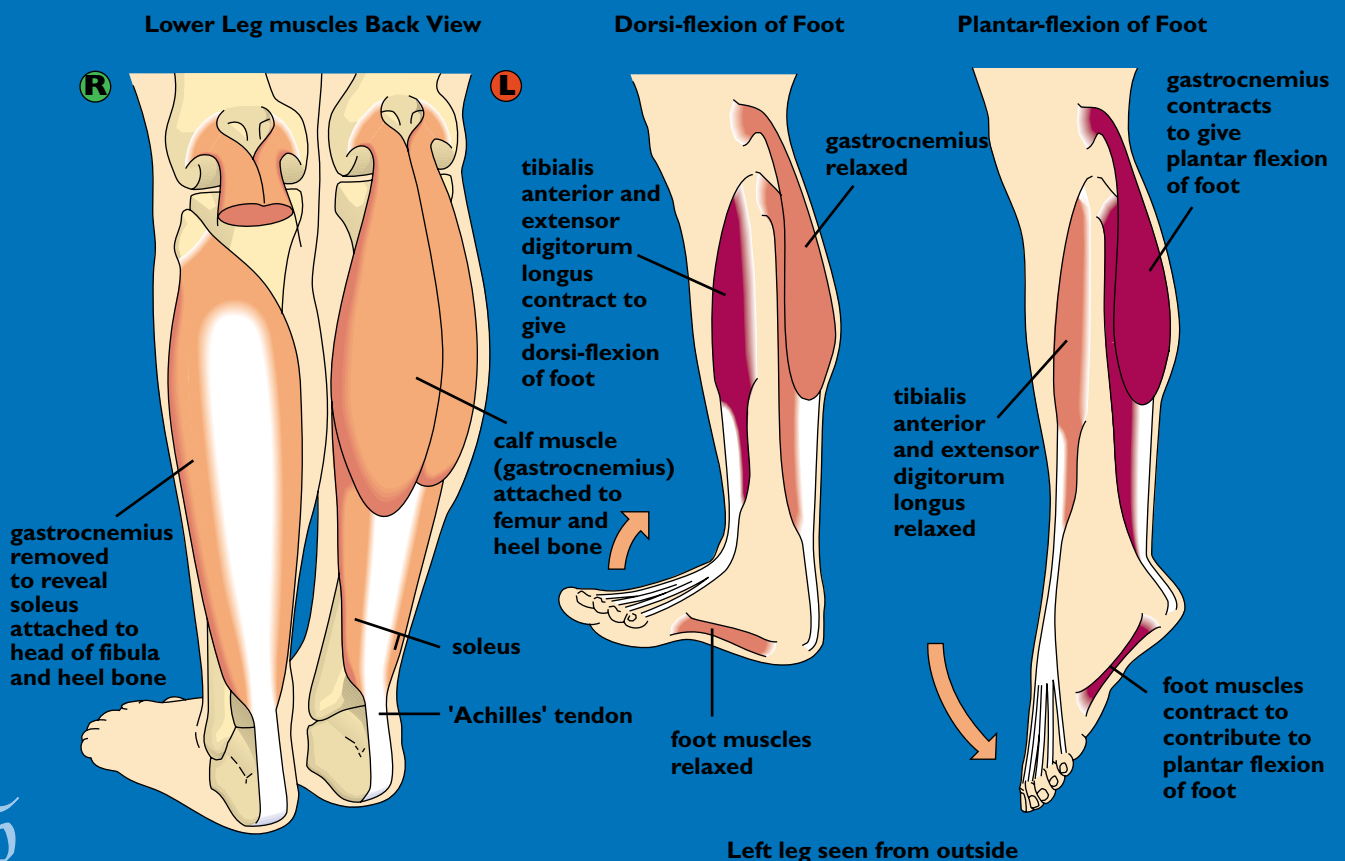


Pronation, Supination, Dorsi-flexion & Planatar-flexion of the Foot

9



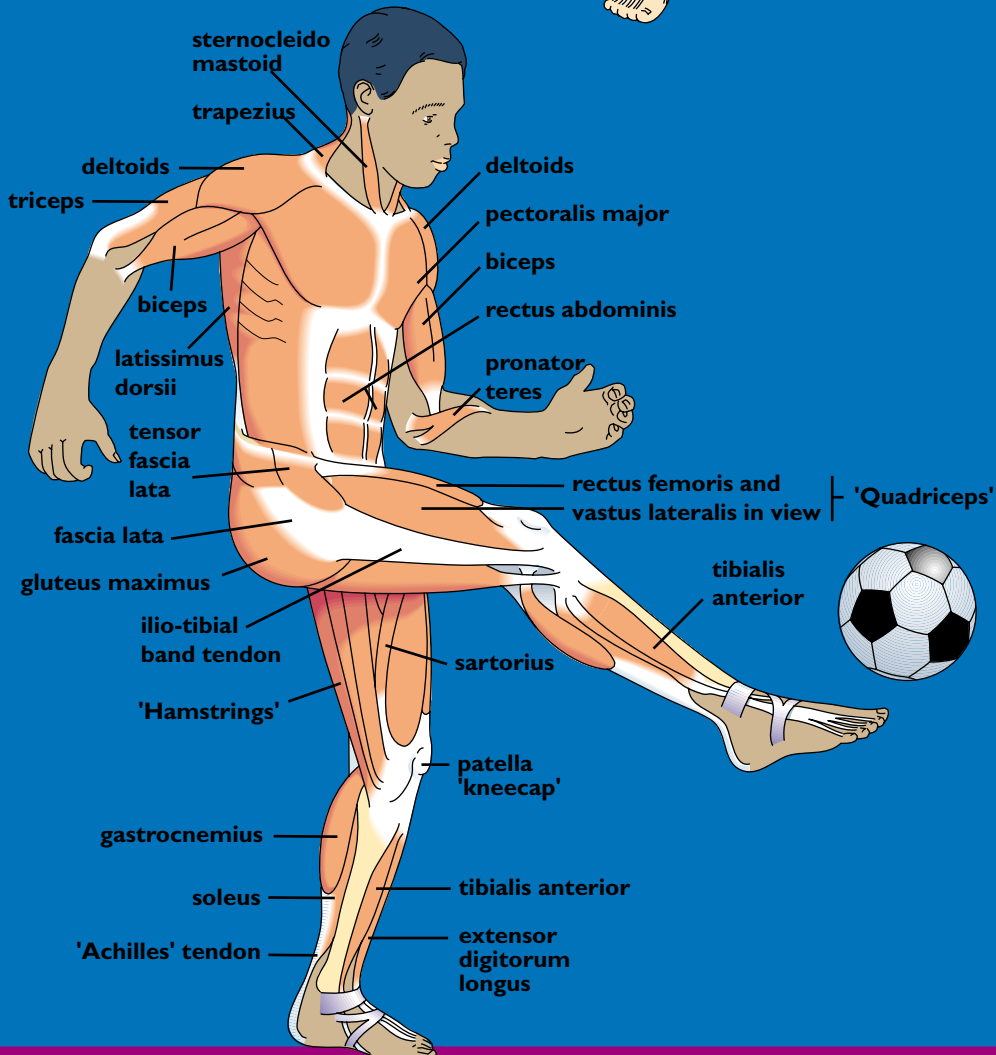
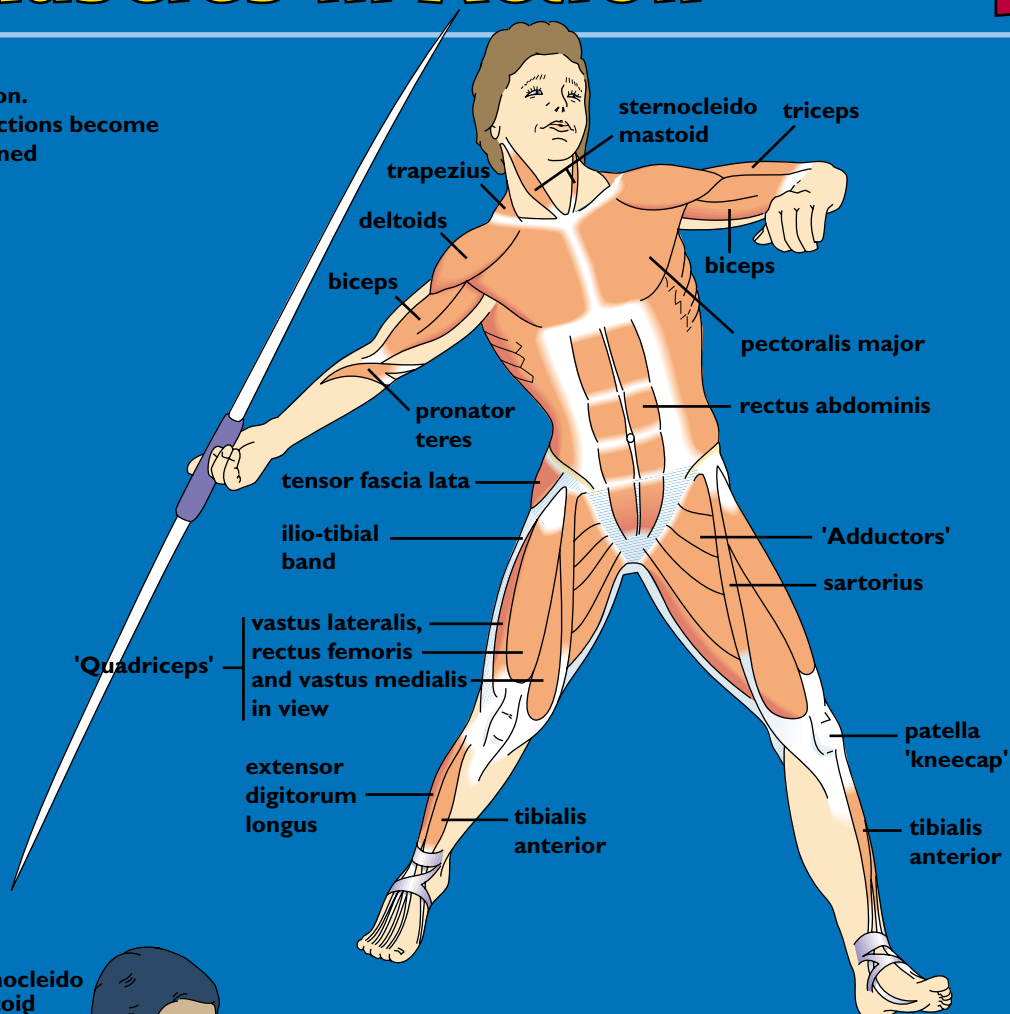
Major muscles of the lower leg, used in pronation, supination, dorsi-flexion, and planatar-flexion of the foot.



Major Muscles in Action

10

Major muscles in action.
Simple antagonistic actions become
complex when combined

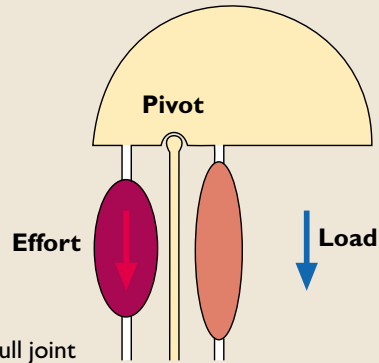


1 2 3 = P L E

1st Order Lever

Pivot (fulcrum) between effort and load

L - P - E

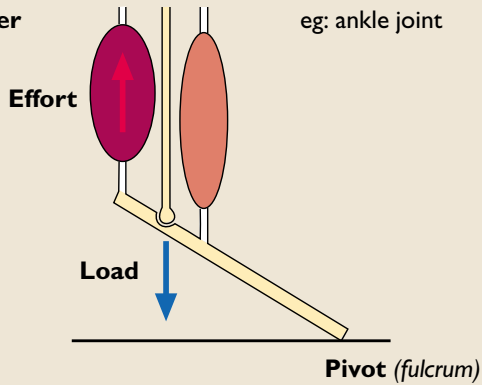


eg: atlas vertebrae to skull joint

2nd Order Lever

Load between Effort and Pivot

E - L - P

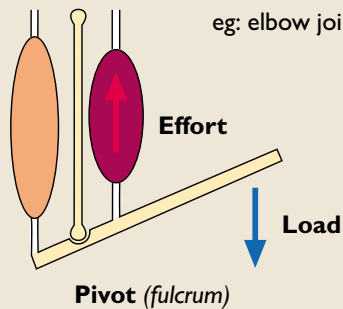


eg: ankle joint

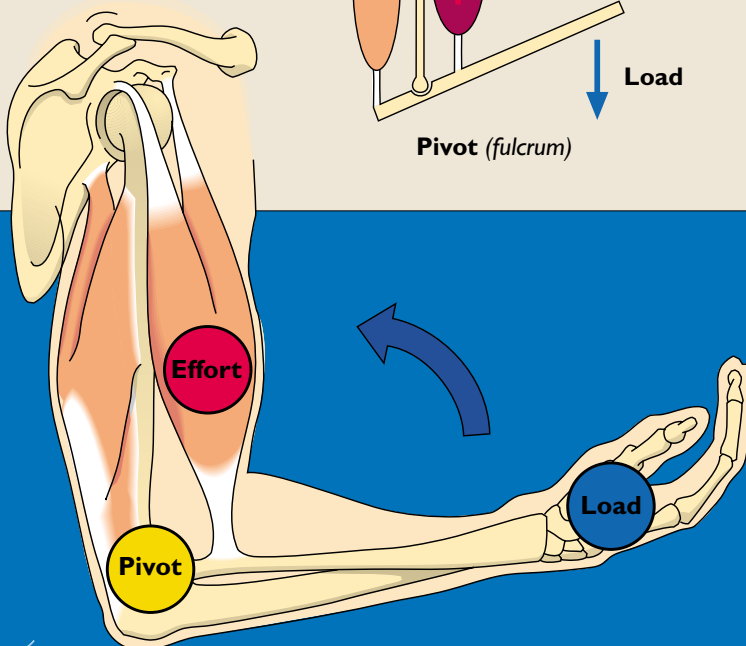
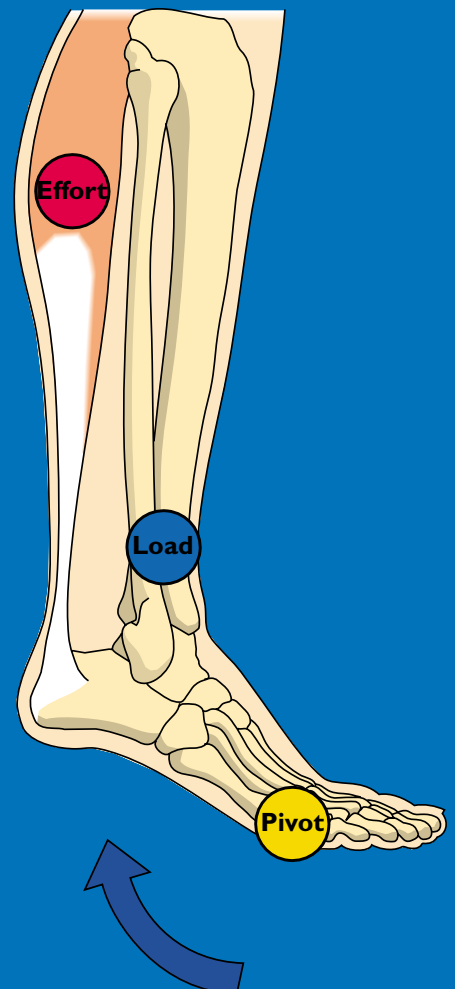
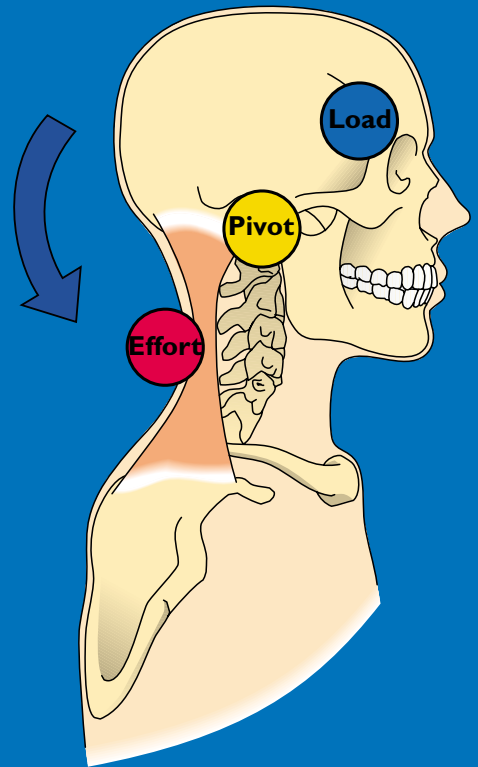
3rd Order Lever

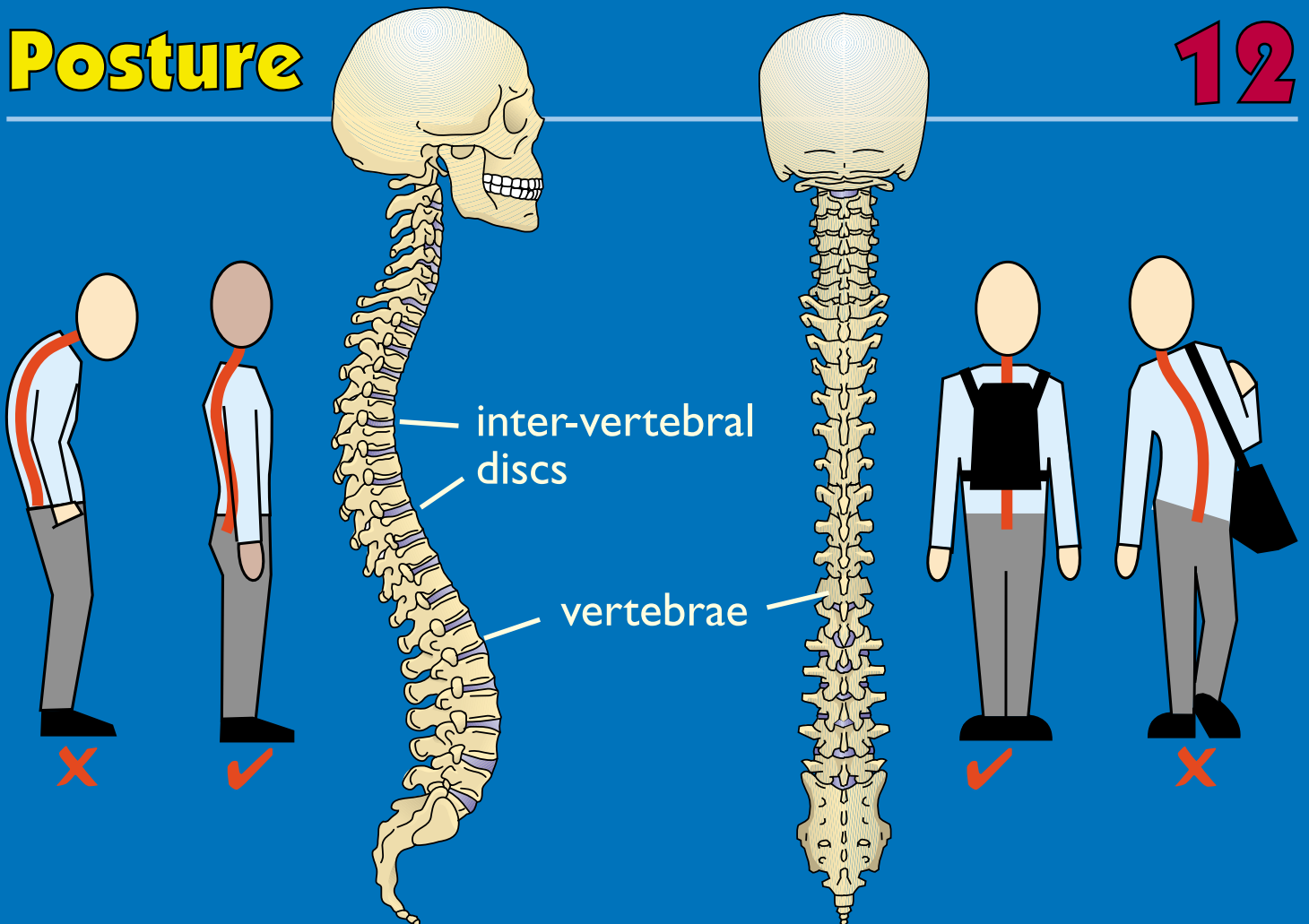
Effort between Load and Pivot

P - E - L



eg: elbow joint





Right hand side
Showing double 'S' curve of the spine

Back view
Showing straight alignment of the spine

